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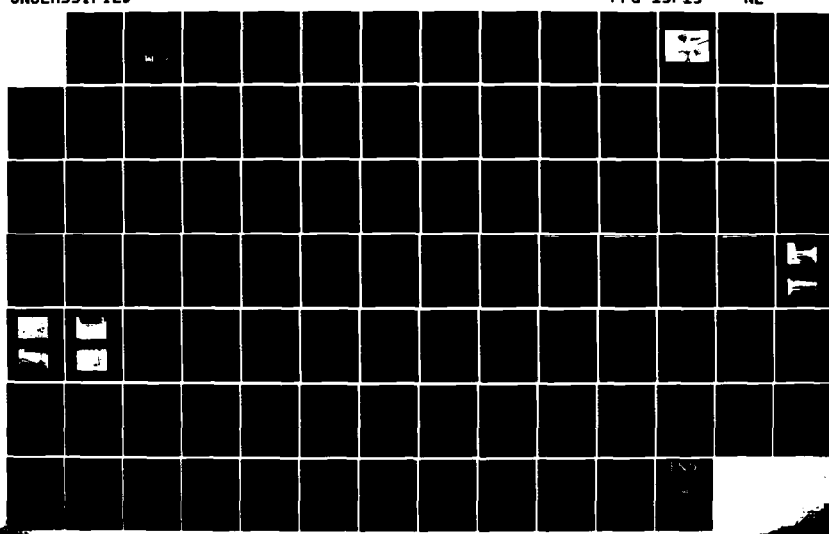
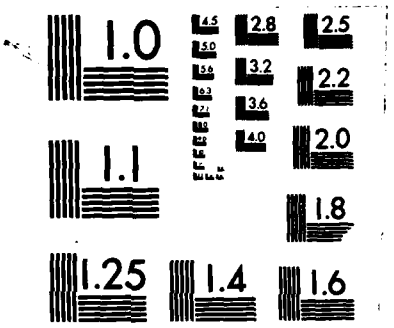




(2)

MERRIMACK RIVER BASIN

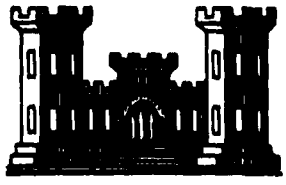
LOUDON, NEW HAMPSHIRE

SANBORN POND OUTLET DAM

NH 00182

NHWRB NO. 143.10

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MAY 1980

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Visual

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Merrimack River Basin,
Louden, New Hampshire,
Sanborn Brook.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is an earthen embankment structure about 265 ft. long and a maximum height of 16.5 ft. The dam is considered to be in poor condition with some major concern which must be corrected. It is intermediate in size with a significant hazard potential.

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SANBORN POND OUTLET DAM
NH 00182
NHWRB 143.10

MERRIMACK RIVER BASIN
LOUDON, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No: NH 00182

Name of Dam: Sanborn Pond Outlet Dam

Town: Loudon

County and State: Merrimack, New Hampshire

Stream: Sanborn Brook

Date of Inspection: March 25, 1980

Sanborn Pond Outlet dam is an earthen embankment structure about 265 feet in overall length and a maximum height of 16.5 feet from crest of dam to downstream toe. The upstream and downstream faces consist of a 2 feet thick vertical dry stone masonry wall which extends the full height of the dam. Located about 105 feet from the left abutment is the principal spillway which consists of a 19 feet long spillway structure with vertical dry stone masonry training walls and flashboards. The top of the permanent crest and the faces of the training walls are lined with rough cut lumber. Located to the right of center of the dam is the principal intake structure and low level outlet which consists of a U-shaped concrete wall and a cast iron penstock which passes through the dam and discharges under the mill building.

The dam impounds Sanborn Pond and the discharge flows through Sanborn Brook in a southerly direction approximately 5.5 miles to the Suncook River. The dam was originally constructed to supply water power to a grist mill, but presently serves industrial and recreational purposes. The pond is 0.77 miles in length with a surface area of about 125 acres. The maximum storage capacity is about 1,420 acre-feet.

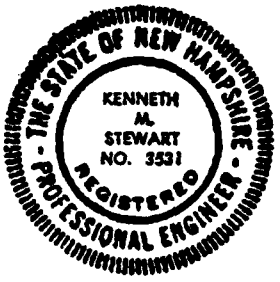
As a result of the visual inspection of this facility, the dam is considered to be in POOR condition. Major concerns are: extensive irregular settlement of the crest of the embankment; poor condition of the vertical dry stone masonry walls which retain the upstream and downstream faces of the embankment; and a wet area at the downstream toe of the dam near the right abutment.

This dam is ~~classified as~~ INTERMEDIATE in size and a SIGNIFICANT hazard structure in accordance with the recommended guidelines established by the Corps of Engineers. The test flood for this dam, therefore, ranges from one-half the Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). Since the dam falls on the lower end of the intermediate size range, the 1/2 PMF was

utilized for this hydrologic analysis. The test flood inflow was estimated to be 3,225 cfs and resulted in a routed test flood outflow equal to 1,990 cfs which would overtop the dam crest by about 3.7 feet. The maximum spillway capacity (with flashboards in place) with the water level at the dam crest was estimated to be 200 cfs, or about 10 percent of the routed test flood outflow. An assumed breach with the pond surface at the dam crest would cause appreciable damage to the saw mill located just below the dam and the possible loss of a few lives of individuals working at the saw mill.

It is recommended that the owner engage a qualified registered engineer to investigate the cause of the irregular settlement of the crest of the dam and the poor alignment of the dry stone masonry face walls; investigate the wet area at the downstream toe of the dam near the right abutment; specify and oversee procedures for the removal of trees and their root systems from the dam and downstream toe; and perform a detailed hydrologic-hydraulic investigation to assess further the potential of overtopping the dam and the need for and the means to increase project discharge capacity. It is also recommended that the owner repair the foundation of the mill building in the discharge channel, remove the brush that has been dumped on the upstream and downstream sides of the embankment between the spillway and the left abutment, replace the wood plank lining at the spillway training walls, repair the service bridge, remove waterlogged debris from the spillway approach channel and remove the wood beam spanning the spillway approach channel.

The recommendations and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.



Kenneth M. Stewart
Project Manager
N.H.P.E. 3531

S E A Consultants Inc.
Rochester, New Hampshire

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and

rarity of such a storm event, finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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OVERVIEW PHOTO - SANBORN POND OUTLET DAM

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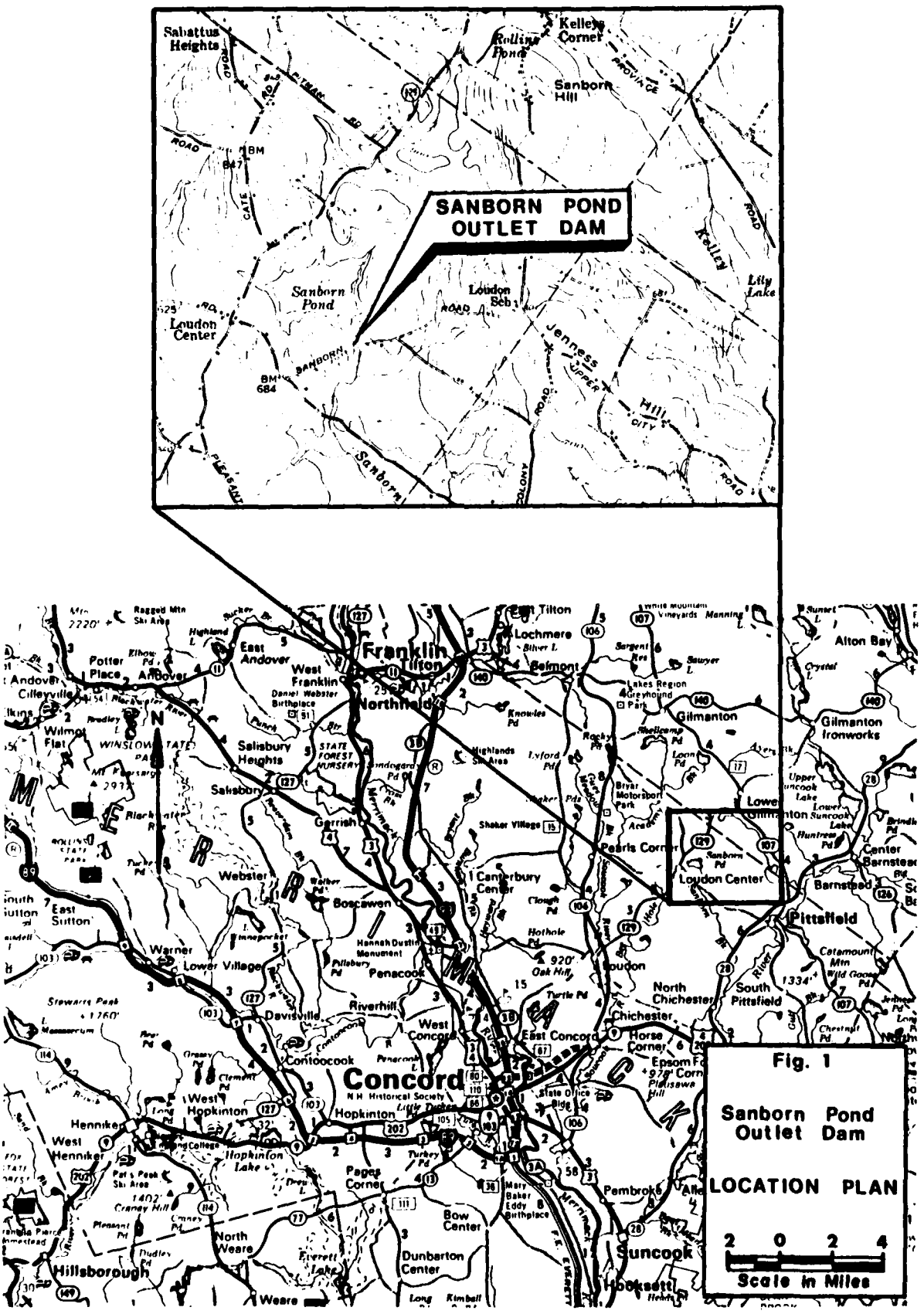

SANBORN POND
OUTLET DAM
Sabattus Heights
Kelley Corner
Rolling Pond
Sanborn Hill
Sanborn Pond
Loudon Center
Loudon Sch
Jenness Upper Hill
Lily Lake
Kelley Road
Franklin
Tilton
Northfield
Concord
N H Historical Society
Hopkinton
Hopkinton Lake
Loudon
Pittsfield
Suncook
Hillsborough
Fig. 1
Sanborn Pond
Outlet Dam
LOCATION PLAN
2 0 2 4
Scale in Miles

X

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
SANBORN POND OUTLET DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. S E A Consultants Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to S E A Consultants Inc. under a letter of November 5, 1975 from William Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C0008 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams

(3) To update, verify and complete the National Inventory of Dams

1.2 Description of Project

a. Location. Sanborn Pond Outlet Dam is located in the town of Loudon, New Hampshire, at the southeast corner of Sanborn Pond. The dam impounds water from Sanborn Pond and the spillway discharge flows in a southerly direction through Sanborn Brook for about 60 feet where it passes under Sanborn Road and discharges into a saw mill retention pond. Sanborn Brook continues in a southerly direction for about 5.5 miles to the Suncook River. The dam is shown on U.S.G.S. Quadrangle, Gilmanton, New Hampshire, with coordinates approximately at N 43°20'03", W 71°23'05", Merrimack County, New Hampshire (See location plan).

b. Description of Dam and Appurtenances. Sanborn Pond Outlet Dam is an earthen embankment structure with a maximum height of approximately 16.5 feet high from crest of dam to downstream toe and about 265 feet long overall. The upstream and downstream faces consist of a 2 feet thick vertical dry stone masonry wall which extends the full height of the dam. The crest width is approximately 16 feet.

Located about 105 feet from the left abutment is the principal spillway which consists of a 19 feet long spillway structure with vertical dry stone masonry training walls and flashboards. The flashboards have been securely nailed to wood supports for the service bridge and cannot be easily removed. The top of the permanent crest and the faces of the training walls are lined with rough-cut lumber.

Located to the right of center of the dam is the principal intake structure which consists of a U-shaped concrete wall about 18 inches thick. A 30-inch diameter and 28-inch diameter cast iron penstock are located through the face of this wall and were formerly used to supply water to power an old grist mill. The waterwheel to the mill has since been removed and the 28-inch diameter penstock has been made inoperable by planking over the inlet.

Located directly on top of and behind the intake structure is the old grist mill which is supported in part by the intake structure and dam, and in part by dry stone masonry walls in the downstream channel.

c. Size Classification. Intermediate (Height - 16.5 feet; storage - 1,420 acre-feet) based on storage (greater than or equal to 1,000 acre-feet and less than 50,000 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. Significant Hazard. An assumed breach in the Sanborn Pond Dam would increase the stage of the pond immediately below the dam by nearly 10 feet. The dam impounding this pond would be overtopped by 6 to 7 feet, and the saw mill at this dam would be inundated. The failure discharge would cause appreciable damage to the saw mill and may result in failure of the dam at the saw mill. The loss of a few lives of individuals working at the saw mill is possible.

e. Ownership. The dam was built in 1830 as part of a grist mill and is owned by John A. Sanborn, RFD #2, Salmon Mill Farm, Pittsfield, New Hampshire 03263. Telephone No. (603) 435-8608.

f. Operator. The dam is maintained and operated by John A. Sanborn, RFD #2, Salmon Mill Farm, Pittsfield, New Hampshire 03263, Telephone No. (603) 435-8608.

g. Purpose of Dam. The original purpose of the dam was to supply water power to a grist mill. The waterwheel and gears have since been removed, and the dam is now used for industrial purposes to regulate the water level of the saw mill retention pond immediately downstream. The dam also serves recreational purposes.

h. Design and Construction History. No information regarding the original design or construction of the dam was found. It is believed that the dam was built in 1830 to supply power to a grist mill. The waterwheel was removed and the mill abandoned sometime before 1934.

i. Normal Operating Procedures. The Sanborn Pond Outlet Dam is used primarily for the retention of Sanborn Pond, which acts as an industrial supply of water for a saw mill immediately downstream. The normal operating procedure for this dam is to keep the flashboards permanently in place and to regulate the penstock gate as required to maintain the water level in the saw mill retention pond.

1.3 Pertinent Data

a. Drainage Area. The drainage area above Sanborn Pond Outlet Dam covers nearly 4.3 square miles (approximately 2,750 acres). The topography in the basin is quite variable, consisting of steeply to moderately sloped terrain surrounding Sanborn Pond and swampy areas which are found in the upper (northern) two-thirds of the drainage area. The drainage basin is predominantly tree covered and generally undeveloped. The development which does exist consists primarily of residences located along the town roads and NH Route 129 which transect the drainage basin.

b. Discharge at Damsite. Discharge at the damsite normally occurs over the flashboards (set at an elevation of 670.0 feet) which have been installed above the 19 feet long permanent spillway weir crest. Wood supports for the deck over the spillway occupy approximately 2 feet of the space between the spillway training walls; consequently, the effective spillway weir length is 17 feet. The flashboards are securely nailed to these wood supports, and cannot be easily removed. A 30-inch diameter penstock gate is located in the dam face between the spillway and the right abutment. The gate was operable and slightly open at the time of inspection. This gate would allow the pond to be lowered to an approximate elevation of 658.5 feet.

(1) The capacity of the penstock gate was estimated to be 84 cfs with the water surface at the top of the dam (elevation 672.5 feet) and 96 cfs with the water surface at the test flood elevation (elevation 676.2 feet).

(2) Maximum known flood at damsite - unknown.

(3) The ungated spillway capacity with the water surface elevation at the top of the dam (elevation 672.5 feet) was estimated to be 200 cfs with the flashboards in place and 315 cfs with the flashboards removed.

(4) The ungated spillway capacity with the water surface elevation at the test flood elevation (Elevation 676.2 feet) was estimated to be 710 cfs with the flashboards in place and 905 cfs with the flashboards removed.

(5) Gated spillway capacity at normal pool elevation - N/A

(6) Gated spillway capacity at test flood elevation - N/A

(7) The total capacity of the spillway (flashboards in place) at the test flood elevation (Elevation 676.2 feet) was estimated to be 710 cfs.

(8) The total project discharge at the top of the dam (Elevation 672.5 feet) was estimated to be 200 cfs. (with penstock closed)

(9) The total project discharge at the test flood elevation (Elevation 676.2 feet) was estimated to be 1990 cfs. (with penstock closed)

c. Elevation. (feet NGVD) based on an elevation 670.0 shown on U.S.G.S quad sheet assumed to be pool elevation at top of flashboards.

(1) Streambed at toe of dam - 657.8

(2) Bottom of cutoff - unknown

(3) Maximum tailwater - unknown

(4) Normal pool - 670.0

(5) Full flood control pool - N/A

(6) Spillway crest (flashboards in place) 670.0
(flashboards removed) 668.9

(7) Design surcharge (Original Design) - unknown

(8) Top of dam - elevation varies - 672.5 (min.), 674.3 (max.)

(9) Test flood surcharge - 676.2

d. Reservoir (Length in feet)

(1) Normal pool - 4,060

(2) Flood control pool - N/A

(3) Spillway crest pool - 4,025 (permanent crest)

(4) Top of dam - 4,140

(5) Test flood pool - 4,255

e. Storage (acre-feet)

(1) Normal pool - 1,100

(2) Flood control pool - N/A

(3) Spillway crest pool - 965 (permanent crest)

(4) Top of dam - 1,420

(5) Test flood pool - 1,915

f. Reservoir Surface(acres)

(1) Normal pool - 125

(2) Flood control pool - N/A

(3) Spillway crest - 123 (permanent crest)

(4) Test flood pool - 138

(5) Top of dam - 130

g. Dam

(1) Type - earthen embankment between two dry stone masonry walls

(2) Length - 265 feet overall

(3) Height - 16.5 feet maximum

(4) Top Width - 16 feet minimum

(5) Side Slopes - vertical dry stone masonry walls upstream and downstream

(6) Zoning - unknown

(7) Impervious Core - unknown

(8) Cutoff - unknown

(9) Grout curtain - none

(10) Other - none

h. Diversion and Regulating Tunnel

Not applicable (See Section j below)

i. Spillway

(1) Type - dry stone masonry with wood plank lining

(2) Length of weir - 19 feet (total length)
17 feet (effective length)

(3) Crest elevation - 670.0 (top of flashboards)
668.9 (top of permanent crest)

(4) Gates - N/A

(5) U/S Channel - The upstream channel basically consists of Sanborn Pond with a short approach channel just prior to the flashboards. The banks of the pond are tree-lined and appear to be stable. The short approach channel consists of dry stone masonry training walls, with a wood beam extending between the training walls, and set less than 1 foot above the water surface. The wood beam appears to function as a debris catcher. Considerable waterlogged debris was observed on the bottom of the approach channel.

(6) D/S Channel - The left side of downstream channel bottom is defined by ledge outcroppings for approximately the first 30 feet, and the right channel edge is defined by the dry stone masonry foundation wall for the mill building. About 60 feet downstream, the channel converges with the discharge from the penstock and passes beneath Sanborn Road through a stone abutment and wood planked bridge into a small pond. This small pond is created by a dam associated with a saw mill. Discharge over this dam enters Sanborn Brook, which flows in a southerly direction until its confluence with the Suncook River.

j. Regulating Outlets

(1) Invert - Penstock invert 658.5±

(2) Size - Penstock; 30 inches diameter

(3) Description - cast iron penstock that passes through the dam embankment and discharges under the mill building

(4) Control Mechanism - penstock gate with geared lifting mechanism in mill building

(5) Other - 28-inch diameter cast iron penstock adjacent to 30-inch diameter penstock; inlet is planked over and is not functional

SECTION 2
ENGINEERING DATA

2.1 Design

No design data were disclosed for Sanborn Pond Outlet Dam.

2.2 Construction

No construction records were disclosed.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. No engineering data were available for Sanborn Pond Outlet Dam. A search of the files of the New Hampshire Water Resources Board and direct contact with the owner, revealed a limited amount of recorded information.

b. Adequacy. The final assessments and recommendations of this investigation are based on the visual inspection and the hydrologic and hydraulic calculations.

c. Validity. No engineering data were disclosed to validate.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. Sanborn Pond Outlet Dam impounds a pond of intermediate size. The drainage basin above the dam consists of steeply to moderately sloping terrain surrounding Sanborn Pond and swampy areas which are found in the upper (northern) two-thirds of the drainage area. The drainage area is predominantly tree covered and generally undeveloped.

The field inspection of Sanborn Pond Outlet Dam was made on March 25, 1980. The inspection team consisted of personnel from S E A Consultants Inc. and Geotechnical Engineers, Inc. Inspection checklists completed during the visual inspection are included in Appendix A. At the time of inspection, water was passing approximately 4-1/4 inches deep over the 19 feet wide spillway. The pool elevation was at approximately 670.4 NGVD. The upstream face of the dam could only be inspected above this water level.

b. Dam. Sanborn Pond Outlet Dam is an earthen embankment structure approximately 16.5 feet high from crest of dam to downstream toe and about 265 feet long overall. The upstream and downstream faces consist of a 2 feet thick vertical dry stone masonry wall which extends the full height of the dam. The crest width is approximately 16 feet. In the central portion of the dam, there is a spillway and a penstock intake structure. The penstock passes under an old mill building, which is supported partly by the dam and partly by dry stone masonry foundation walls in the downstream channel.

The crest of the dam between the penstock intake structure and the right abutment is covered with grass. Planks of rough-cut lumber about 2 inches thick and 12 inches wide appear to have been driven more or less vertically into the crest of the embankment from the penstock intake structure for a distance of about 8 feet toward the right abutment. The crest of the embankment appears to have settled irregularly in the vicinity of these driven planks, and the alignment of the planks is irregular.

The crest of the dam between the penstock intake structure and the spillway is covered with grass and weeds. Planks of rough-cut lumber about 2 inches thick and 12 inches wide appear to have been driven more or less vertically into the crest of the embankment between the penstock intake structure and the spillway. The crest of the embankment appears to have settled irregularly and the alignment of the planks is irregular.

The crest of the embankment between the spillway and the left abutment is covered with grass, weeds, and small brush. Some larger brush has been cut. The crest of this section of the embankment appears to have settled irregularly, and the owner stated at the time of inspection that fill had been added on the crest of this section.

The vertical dry stone masonry walls which retain the upstream and downstream faces of the embankment are poorly aligned and have fallen down and are in a state of disrepair in several locations, apparently as the result of long-term displacement and deterioration.

One tree is growing on the upstream side of the embankment crest between the spillway and the left abutment. Many trees are growing at the downstream toe of the embankment between the spillway and the left abutment.

Downstream of the embankment section, near the right abutment, there is a swampy area, with some standing water between the toe of the dam and the dirt road (Sanborn Road) immediately downstream of the dam. It is not possible to determine on the basis of the visual inspection alone whether this swampy area is the result of seepage through and under the dam, or of natural groundwater discharge from the site of the valley at the abutment.

Some cut brush has been dumped on the upstream and downstream sides of the embankment between the spillway and the left abutment.

c. Appurtenant Structures. Located about 105 feet in from the left abutment is the principal spillway which consists of a 19 feet long spillway structure with vertical dry stone masonry training walls and flashboards. The top of the permanent crest is lined with planks of rough-cut lumber about 2 inches thick and is in good shape. The same type of planks line the faces of the stone masonry training walls. The training wall planking is old and deteriorating.

A service bridge extends over the spillway between the left and right training wall. This is a wood structure with no railing and several planks missing between two main wood beams. Most of the bridge planking that remains is rotted.

Vertical wood members between the permanent crest of the spillway and the service bridge above support the flashboards which are located on the upstream face. These flashboards appear to be permanently fixed to the vertical supporting members and appear to be in good shape.

A wood beam extends between the stone masonry walls which define the approach channel to the spillway. This beam is set less than 1 foot above the water surface and appears to function as a debris catcher.

Located to the right of center of the dam is the principal intake structure which consists of a U-shaped concrete wall about 18 inches thick. The intake was formerly used to supply water to power the old grist mill. The concrete structure is in good shape, and the gate is maintained and in operating order.

Located directly on top of and behind the intake structure is the old grist mill which is supported in part by the intake structure and dam, and in part by dry stone masonry walls in the downstream channel. These supporting walls are in such a deteriorated condition that the mill building could collapse into the discharge channel.

d. Reservoir. The slopes of the pond appear to be stable. There appears to be very shallow water upstream of the dam, but it is not possible on the basis of the visual inspection alone to determine whether this is the result of significant sedimentation in the pond.

e. Downstream Channel. The downstream channel bottom is partly ledge outcroppings for approximately the first 30 feet, and the right channel edge is defined by the dry stone masonry foundation wall for the mill building. About 60 feet downstream, the channel converges with the discharge from the penstock and passes beneath Sanborn Road through a stone abutment and wood planked bridge.

3.2 Evaluation

On the basis of the results of the visual inspection, Sanborn Pond Outlet Dam is considered to be in poor condition.

Extensive irregular settlement of the crest of the embankment, the poor condition of the vertical dry stone masonry walls which retain the upstream and downstream faces of the embankment, and the presence of what appears to be a wooden plank cutoff wall in the crest, in the vicinity of the penstock intake structure, all indicate that the embankment is in poor condition and may be unstable.

The presence of a wet area at the downstream toe of the dam near the right abutment may be evidence of seepage through and under the dam.

Trees growing at the downstream toe of the embankment and on the upstream side of the crest may cause seepage and erosion problems if a tree blows over and pulls out its roots, or if a tree dies and its roots rot.

The deteriorating condition of the wood planking lining the spillway training walls, which if allowed to continue, would begin to deteriorate the dry stone masonry training walls behind the wood.

The deteriorating condition of the service bridge over the spillway represents a hazard to anyone using the bridge.

The poor condition of part of the foundation of the mill building in the discharge channel may lead to collapse of the building into the channel.

SECTION 4
OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The Sanborn Pond Outlet Dam is used primarily to create Sanborn Pond. There are no written operational procedures pertaining to the penstock gate.

b. Description of any Warning Systems in Effect. No written warning system exists for the dam.

4.2 Maintenance Procedures

a. General. The owner, Mr. John A. Sanborn, is responsible for the maintenance of the dam. No formal maintenance plan exists, although it should be noted that at the time of the inspection the owner was in the process of repairing the spillway planking and penstock gate stem.

b. Operating Facilities. No formal plan for maintenance of operating facilities was disclosed.

4.3 Evaluation

The current operation and maintenance procedures for the Sanborn Pond Outlet Dam are inadequate to ensure that all problems encountered can be remedied within a reasonable period of time. The owner should establish a written operation and maintenance procedure, as well as a warning system to follow in event of flood flow conditions or imminent dam failure.

SECTION 5
EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General. Sanborn Pond Outlet Dam is an earthen embankment structure approximately 16.5 feet high from crest of dam to downstream toe and about 265 feet long overall. Located about 105 feet from the left abutment is the principal spillway. The spillway measures 19 feet between the training walls and has an effective weir length of 17 feet. The permanent crest of the spillway is set at an elevation of 688.9 feet. Flashboards have been installed above the permanent crest to an elevation of 670.0. These flashboards have been securely nailed to the wood supports for the service bridge, and cannot be easily removed. Located to the right of the spillway is a U-shaped concrete intake structure with a 30-inch diameter penstock gate. The gate was operable at the time of inspection.

A number of swampy areas and one small pond are located in the upper (northern) two-thirds of the drainage area. Consequently, stormwater deposited in the upper portion of the drainage basin would be intercepted by these storage areas before flowing to Sanborn Pond. The dam impounding Sanborn Pond is classified as intermediate in size and has a maximum storage capacity of approximately 1,420 acre-feet.

5.2 Design Data. No hydrological or hydraulic design data were disclosed.

5.3 Experience Data. No experience data were disclosed. Maximum flood flows or elevations are unknown.

5.4 Test Flood Analysis. Due to the absence of detailed design and operational information, the hydrologic evaluation was performed utilizing data gathered during field inspection, watershed size and an estimated test flood determined from the Corps of Engineers guide curves. For this dam (intermediate size and significant hazard), the test flood ranges from one-half the Probable Maximum Flood (1/2 PMF) to the full Probable Maximum Flood (PMF). Since the dam falls on the low end of the intermediate size range, the 1/2 PMF was selected for this hydrologic analysis. Since the drainage area consists of a combination of steeply to moderately sloped and flat terrain, and since there is a considerable amount of storage available in the swampy areas upstream from Sanborn Pond, a point about mid-way between the "rolling" curve and "flat" curve, from the Corps of Engineers set of guide curves, was used to estimate the maximum probable flood peak flow rate.

Based on an estimated maximum probable flood peak flow rate of 1,500 cfs per square mile and a drainage area of 4.3 square miles, the test flood inflow was estimated to be 3,225 cfs. The test flood was routed through the reservoir in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The reservoir water surface was assumed to be at elevation 670.0 prior to the flood routing. Also, since the penstock gate is normally closed or only slightly open, it was assumed that the discharge through the penstock would be neglible and, therefore, was not included

in the analysis. The routed test flood outflow was estimated to be 1,990 cfs. This analysis indicated that the dam crest would be overtopped by 3.7 feet. The maximum spillway capacity (with flashboards in place) with the water level at the dam crest was estimated to be 200 cfs, which is only about 10 percent of the routed test flood outflow.

5.5 Dam Failure Analysis. The impact of dam failure with the reservoir surface at the dam crest was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs published by the Corps of Engineers. The analysis covered a reach extending approximately 4 miles downstream. Based on this analysis, the Sanborn Pond Outlet Dam has been classified as a significant hazard.

A major breach in the Sanborn Pond Outlet Dam would increase the stage of the pond immediately below the dam by nearly 10 feet. The dam impounding this pond would be overtopped by 6 to 7 feet, and the saw mill at this dam would be inundated. The failure discharge would cause appreciable damage to the saw mill and may result in failure of the dam at the saw mill. The loss of a few lives of individuals working at the saw mill is possible. Below the saw mill dam, the stream channel passes beneath a series of town roads and one state highway before converging with the Suncook River. Youngs Hill Road, which is located about 0.7 miles below the dam, would be overtopped by about 6 feet of water. This could result in significant damage to the road. Beyond this road, the stream channel widens and the failure discharge reduces considerably due to the storage along the channel. Consequently, it is not anticipated that appreciable damage would result further downstream, since no structures are located near enough to the channel to be damaged.

SECTION 6
EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The visual examination indicates the following potential structural problems:

(1) Extensive irregular settlement of the crest of the embankment, the poor condition of the vertical dry stone masonry walls which retain the upstream and downstream faces of the embankment, and the presence of what appears to be a wooden-plank cutoff wall in the crest in the vicinity of the penstock intake structure all indicate that the embankment is in poor condition and may be unstable.

(2) The presence of a wet area at the downstream toe of the dam near the right abutment may be evidence of seepage through and under the dam.

(3) Trees growing at the downstream toe of the embankment and on the upstream side of the crest may cause seepage and erosion problems if a tree blows over and pulls out its roots, or if a tree dies and its roots rot.

(4) The deterioration of the wood planking lining the spillway training walls which could collapse and expose the stone training wall behind the wood to erosion.

(5) The poor condition of the mill building foundation in the discharge channel that may lead to the collapse of the building into the discharge channel.

The presence of cut brush on the upstream and downstream sides of the embankments makes it impossible to inspect those areas adequately.

6.2 Design and Construction Data. It is believed that the dam was built in 1830 to supply power to a grist mill. No information regarding the original design or construction of the dam was found.

6.3 Post-Construction Changes. The dam was originally built to supply power to a grist mill. The waterwheel was removed and the mill abandoned sometime before 1934.

6.4 Seismic Stability. This dam is located is Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination indicates that Sanborn Pond Outlet Dam is in poor condition. The major concerns with respect to the integrity of the dam are:

(1) Irregular settlement of the crest of the embankment.

(2) Poor condition of the dry stone masonry walls which retain the upstream and downstream faces of the embankment.

(3) Wet area at the downstream toe of the dam near the left abutment.

(4) Trees growing at the downstream toe and on the upstream edge of the crest of the embankment.

(5) Poor condition of the wood plank lining of the spillway training walls.

(6) Poor condition of the foundation of the mill building in the discharge channel.

b. Adequacy of Information. Brush dumped on the upstream and downstream sides of the embankment between the spillway and the left abutment makes it impossible to inspect those areas adequately. With this exception, the information available from the visual inspection and hydraulic computations is adequate to identify the problems mentioned in 7.2. These problems will require the attention of registered professional engineer qualified in the design and construction of dams who will have to make additional engineering studies to design or specify remedial measures. No additional information is needed for the purposes of this Phase I investigation.

c. Urgency. The owner should implement the recommendations in 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations

The owner should retain a registered professional engineer qualified in the design and construction of dams to:

(1) Investigate the cause of the irregular settlement of the crest of the dam, the poor alignment of the dry stone masonry walls which retain the upstream and downstream faces of the embankment, and the condition of the embankment in the vicinity of the spillway and penstock intake structure, and design remedial measures if needed.

(2) Investigate the wet area at the downstream toe of the dam near the right abutment and design remedial measures if needed.

(3) Specify and oversee procedures for removal of trees and their root systems from the dam and downstram toe.

(4) Inspect the spillway under no-flow conditions.

(5) Perform a detailed hydrologic/hydraulic investigation to assess further the potential of overtopping the dam and the need for and the means to increase project discharge capacity.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

(1) Repair the foundation of the mill building in the discharge channel (or remove the building).

(2) Monitor the wet area at the downstream toe of the dam between the mill building and the right abutment until the recommendation made in 7.2 (2) has been carried out.

(3) Remove the brush that has been dumped on the upstream and downstream sides of the embankment between the spillway and the left abutment.

(4) Replace the wood plank lining at the spillway training walls.

(5) Repair the service bridge.

(6) Remove the waterlogged debris from the spillway approach channel.

(7) Remove the wood beam spanning the spillway approach channel, assuming that it does not function as a debris catcher to keep the spillway clear.

(8) Visually inspect the dam and appurtenant structures once a month.

(9) Establish written maintenance procedures.

(10) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every year.

(11) Establish a surveillance program and gate operating procedure for use during and immediately after heavy rainfall and also a warning program to follow in case of emergency conditions.

7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3

APPENDIX A
INSPECTION CHECKLIST

INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT: Sanborn Pond Outlet Dam, NH

DATE: March 25, 1980

TIME: 2:30 p.m.

WEATHER: Cool, partly cloudy

W.S. ELEV. 670.4 (NGVD) U.S. 658.6 DN.S.

PARTY:

1.	Kenneth Stewart, S E A	6.	
2.	Robert Durfee, S E A	7.	
3.	Bruce Pierstorff, S E A	8.	
4.	Philip Ricardi, S E A	9.	
5.	Ronald Hirschfeld, GEI	10.	

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Structural Stability	K. Stewart/R. Durfee	
2.	Hydrology/Hydraulics	B. Pierstorff/P. Ricardi	
3.	Soils and Geology	R. Hirschfeld	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Dam Embankment NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	672.5
Current Pool Elevation	670.4
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Not paved
Movement or Settlement of Crest	Crest of embankment is irregular
Lateral Movement	Vertical dry stone masonry walls which retain embankment have irregular alignment
Vertical Alignment	Crest is irregular
Horizontal Alignment	Fair
Condition at Abutment and at Concrete Structures	Fair
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	No evidence of trespassing observed
Vegetation on Slopes	Trees growing close to downstream edge of embankment
Sloughing or Erosion of Slopes or Abutments	Some erosion of slopes
Rock Slope Protection - Riprap Failures	Vertical dry stone masonry walls retain embankment
Unusual Movement or Cracking at or near Toe	None observed
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	None observed
Toe Drains	None observed
Instrumentation System	None

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Dike Embankment NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	No dike
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Vegetation on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or near Toes	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Intake Channel NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	Concrete U-shaped intake structure under mill building for cast iron penstock
a. Approach Channel	
Slope Conditions	Good
Bottom Conditions	Not visible beneath pond surface
Rock Slides or Falls	None observed
Log Boom	None
Debris	None observed
Condition of Concrete Lining	Not applicable
Drains or Weep Holes	None
b. Intake Structure	
Condition of Concrete	Good
Stop Logs and Slots	No stoplogs or slots

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Control Tower NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	Control works located on top of concrete intake structure inside mill building
a. Concrete and Structural	
General Condition	Good
Condition of Joints	None
Spalling	None
Visible Reinforcing	None
Rusting or Staining of Concrete	None
Any Seepage or Efflorescence	None visible
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	Unknown - gate partially open at time of inspection
Cracks	None visible
Rusting or Corrosion of Steel	None visible
b. Mechanical and Electrical	
Air Vents	None
Float Wells	None
Crane Hoist	None
Elevator	None
Hydraulic System	None
Service Gates	Gate partially open at time of inspection -mechanism operable
Emergency Gates	See service gates
Lightning Protection System	None
Emergency Power System	None
Wiring and Lighting System	None

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Transition and Conduit NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	Transition through mill building
General Condition of Concrete	Good
Rust or Staining on Concrete	None
Spalling	None visible
Erosion or Cavitation	None visible
Cracking	None visible
Alignment of Monoliths	Not applicable
Alignment of Joints	Good
Numbering of Monoliths	Not applicable

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Outlet Structure NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	Outlet under mill building constructed of dry stone masonry walls
General Condition of Concrete	Not applicable
Rust or Staining	Not applicable
Spalling	Not applicable
Erosion or Cavitation	None visible
Visible Reinforcing	Not applicable
Any Seepage or Efflorescence	None visible
Condition at Joints	Dry stone masonry
Drain Holes	None
Channel	
Loose Rock or Trees Overhanging Channel	Some trees overhang channel
Condition of Discharge Channel	Fair

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Spillway Weir NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Conditions	Fair - Considerable debris in approach channel; owner reports some beaver activity
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Not visible beneath pond surface
b. Weir and Training Walls	Training walls are constructed of dry stone masonry with wood plank facing
General Condition of Concrete	Not applicable
Rust or Staining	Not applicable
Spalling	Not applicable
Any Visible Reinforcing	Not applicable
Any Seepage or Efflorescence	None
Drain Holes	None
c. Discharge Channel	
General Condition	Fair
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Some trees overhang channel
Floor of Channel	Natural - ledge and stone
Other Obstructions	None observed

INSPECTION CHECK LIST

PROJECT: Sanborn Pond Outlet Dam, NH DATE: March 25, 1980

PROJECT FEATURE: Service Bridge NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SERVICE BRIDGE	Service bridge (walkway) located over spillway weir
a. Super Structure	
Bearings	Longitudinal members bear on dry stone masonry training walls
Anchor Bolts	No anchor bolts
Bridge Seat	Dry stone masonry in fair shape
Longitudinal Members	Two 10-inch deep wood beams
Under Side of Deck	Longitudinal members in fair shape
Secondary Bracing	Vertical members from spillway crest in fair shape
Deck	Wood planks, several rotted and missing
Drainage System	None
Railings	No railings
Expansion Joints	No expansion joints
Paint	No paint. All wood members weathered.
b. Abutment & Piers	Dry stone masonry training walls act as service bridge abutments
General Condition of Concrete	Not applicable
Alignment of Abutment	Good
Approach to Bridge	Good
Condition of Seat & Backwall	Fair

APPENDIX B

ENGINEERING DATA

AVAILABLE ENGINEERING DATA

No Engineering Data other than past inspection reports from the State of New Hampshire Water Resource Board were available.

PAST INSPECTION REPORTS

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Loudon Dam Number: 143.10

Inspected by: — Date: 24 Jun 1974

Local name of dam or water body: Sanborn Pond Outlet

Owner: Sanborn Address: _____

Owner (was) was not interviewed during inspection.

Drainage Area: _____ sq. mi. Stream: _____

Pond Area: _____ Acre, Storage _____ Ac-Ft. Max. Head _____ Ft.

Foundation: Type _____, Seepage present at toe - Yes/No, _____

Spillway: Type Standby, Freeboard over perm. crest: _____,

Width _____, Flashboard height _____,

Max. Capacity _____ c.f.s.

Embankment: Type _____, Cover _____ Width _____,

Upstream slope 0 to 1; Downstream slope _____ to 1

Abutments: Type Stonewall, Condition: Good (Fair) Poor

Gates or Pond Drain: Size 4X4 Capacity _____ Type _____

Lifting apparatus _____ Operational condition good

Changes since construction or last inspection: _____

Downstream development: Bridge Below

This dam (would) would not be a menace if it failed.

Suggested reinspection date: _____

Remarks: Old Grist Mill

NEW HAMPSHIRE WATER CONTROL COMMISSION

REPORT ON DAM INSPECTION

TOWN Loudon DAM NO. 143.10 STREAM Sanborn Brook

OWNER Albin J. Sanborn ADDRESS Pittsfield, N.H.

In accordance with Section 20 of Chapter 133, Laws of 1937, the above dam was inspected by me on 8/24/50 ~~accompanied by~~

NOTES ON PHYSICAL CONDITION.

Abutments Good

Spillway Good

Gates Not used— leak a little

Other

CHANGES SINCE LAST INSPECTION None

FUTURE INSPECTIONS Yes

This dam (is) ~~(is not)~~ a menace because of small highway bridge opening between it and dam #143.11

REMARKS 9" water over spillway, staplogged.

Copy to Owner	Date

Francis C. Moore
INSPECTOR

(Additional Notes Over)

FORM E2 8252

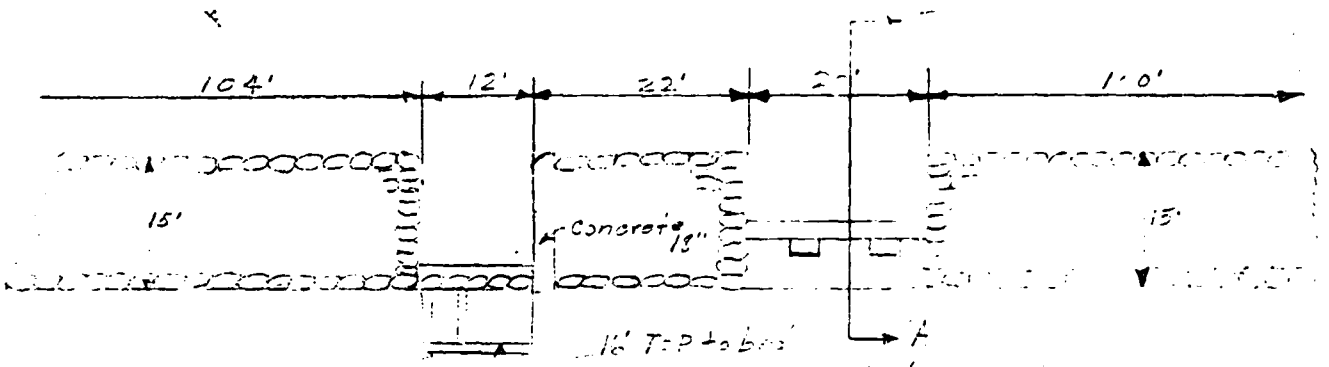
NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

PROJECT FILE 143-10

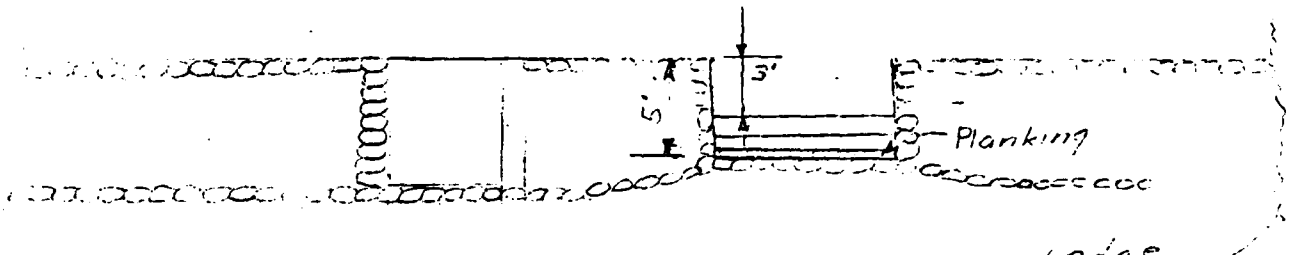
SUBJECT SANBORN Pond outLET LOUDON ACC.

MERRIMACK SUNCOOK A. J. SANBORN Pittsfield N. H.

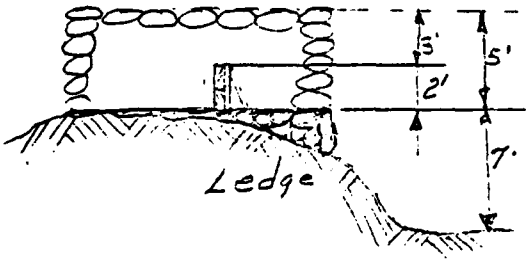
COMPUTER CHECKER AR CONT. FROM ACC. CONT. ON ACC. SUMMARY ON ACC. DATE 8/1/39



16' T.P to be
2. Penstocks will be taken
Plan Scale 1"=20'-0"



Elevation
Scale 1"=20'-0"



Section A-A
Scale 1"=10'-0"

Form No. E61A 8442

NEW HAMPSHIRE WATER CONTROL COMMISSION 4/6 RECORD OF DAM NO. 143:10

Town Loudon: County Merrimack: Local Name Sanborn Pond Outlet

Function of Dam Storage Recreation Type Rock Wall Rock Fill

Primary Basin Merrimack R.: Sec. Basin Suncook R.: Local Stream Sanborn Brook

Drainage Area, Total 2.5 sq. mi.: Controlled ..... sq. mi.: Net Uncontrolled ..... sq. mi.:

Reservoir Area, Full Pond 104 acres: At Max. Drawdown ..... acres:

Reservoir Capacity 54.45 mcf.: 1250 ac. ft.: ..... in. net D. A.: ..... in. Total D. A.:

Overall Length of Dam 258 ft.: Max. Depth Water at Dam 11 ft.:

Net Spillway Length 20 ft.: Minimum Freeboard 5 ft.:

Spillway Capacity 900 cfs.: 34 cfs. per sq. mi.:

Highest Flood Flow of Record ..... cfs.: ..... cfs. per sq. mi.: Date .....

Estimated Maximum Probable Flood ..... cfs.:

REMARKS: Small leak thru stones under plank spillway now being repaired

Card Prepared by C.F.O.: Checked by .....: Approved for File .....: Date 10/9/39

OWNER A. J. Sanborn: ADDRESS Pittsfield N.H.: CASE NO. .....:

Contractor .....: Address .....

Construction Record

Date Office-Routine		Inspection During Construction					
		Date	Inspector	Memo	Date	Inspector	Memo
Application Received	.....	.....	.....	.....	.....	.....	.....
Board Approval	.....	.....	.....	.....	.....	.....	.....
Authorization Sent	.....	.....	.....	.....	.....	.....	.....
Final Plans Rec'd	.....	.....	.....	.....	.....	.....	.....
Final Approval-Board	.....	.....	.....	.....	.....	.....	.....
Final Approval-Sent	.....	.....	.....	.....	.....	.....	.....
Case Closed	.....	.....	.....	.....	.....	.....	.....

Is Dam a Menace Yes:

Why Road under

Dam Inspection Record

Date	Inspector	Comments	Memo Prepared	Memo Sent To Owner
7/17/39	C.D.C.	Good condition -	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 143.10

Town Loudon : County Merrimack

Stream Sanborn Pond Outlet

Basin-Primary Merrimack R : Secondary Suncook River

Local Name

Coordinates—Lat. 43° 20' + 200 : Long. 71° 25' - 8500

GENERAL DATA

Drainage area: Controlled Sq. Mi.: Uncontrolled Sq. Mi.: Total 3.5 (?) Sq. Mi.

Overall length of dam 258 ✓ ft.: Date of Construction 1830

Height: Stream bed to highest elev. 16 ✓ ft.: Max. Structure 11' ✓ ft.

Cost—Dam : Reservoir

DESCRIPTION D Stonewall—— On Ledge Foundation ✓

Waste Gates

Type

Number : Size ft. high x ft. wide

Elevation Invert : Total Area sq. ft.

Hoist

Waste Gates Conduit

Number : Materials

Size ft.: Length ft.: Area sq. ft.

Embankment

Type

Height—Max. ft.: Min. ft.

Top—Width : Elev. ft.

Slopes—Upstream on: Downstream on

Length—Right of Spillway : Left of Spillway

Spillway

Materials of Construction

Length—Total ft.: Net 20' ✓ ft.

Height of permanent section—Max. 11 ft.: Min. ft.

Flashboards—Type Fixed ✓ : Height 2' high ✓ ft.

Elevation—Permanent Crest : Top of Flashboard

Flood Capacity 700 ~~650~~ cfs.: cfs/sq. mi.

Abutments

Materials:

Freeboard: Max. 5' ✓ ft.: Min. ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER A J Sanborn Pittsfield N H

REMARKS Use—— Conservation—— Recreation Excellent Condition

Menace Bridge below too small

Tabulation By A A N & R L T Date January 25, 1939

3&B21284

Rec'd 10/12

Jacobson	
Holmgren	✓
Return to	
Filed	
File No.	

WATER CONTROL COMMISSION

STATE OF NEW HAMPSHIRE

Concord, New Hampshire

October 17, 1938.

A J Sanborn,
Pittsfield N H

RE: Sanborn Pond Out Dam. W. C. C. No. 143.10

Gentlemen:

In order that we may determine the magnitude and extent of the flood of September 21-24 just passed, we are requesting the various dam owners in the State to supply us with the following information:

1. Was this dam injured? Ans. No

2. If so, to what extent? Ans. none

3. Did all flashboards go out? Ans. none

4. What was the maximum height of water over the permanent crest of spillway? Ans. none

5. At what day and hour did the maximum flood height reach your dam? Ans. ~~[illegible]~~

6. Any other interesting information regarding the flood or rain fall may be given on the back of this sheet, or attach sheets.

Will you please return this letter with as much information as you can give us as promptly as possible. A self-addressed envelope is attached hereto.

We thank you for your cooperation.

Very truly yours,

Richard S. Holmgren

Richard S. Holmgren
Chief Engineer

CDC:GMB
Enc.

Suncook 17B

NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

BASIN Merrimack NO. 10 — 291 — 5-3539
RIVER Sanborn Pond MILES FROM MOUTH D.A.SQ.MI.
TOWN Loudon OWNER Albin J. Sanborn, Pittsfield
LOCAL NAME OF DAM
BUILT 1830 AE DESCRIPTION Double Stone wall — ? (Stone AE)
on Ledge

POND AREA-ACRES 103.88 DRAWDOWN FT. POND CAPACITY-ACRE FT.
HEIGHT-TOP TO BED OF STREAM-FT. 16 MAX. MIN.
OVERALL LENGTH OF DAM-FT. 258 MAX.FLOOD HEIGHT ABOVE CREST-FT.
PERMANENT CREST ELEV.U.S.G.S. LOCAL GAGE
TAILWATER ELEV.U.S.G.S. LOCAL GAGE
SPILLWAY LENGTHS-FT. 20 FREEBOARD-FT. 5.
FLASHBOARDS-TYPE, HEIGHT ABOVE CREST 2' fixed
WASTE GATES-NO. WIDTH MAX. OPENING DEPTH SILL BELOW CREST

REMARKS Condition Good
Mouth Sanborn Bk 16.63 mi. from mouth Suncook R
L 4 Into Sanborn Bk, Suncook R.

Co-ordinates from AE
43° 20' + 100 yds
71° 25' - 2800 yds.

POWER DEVELOPMENT

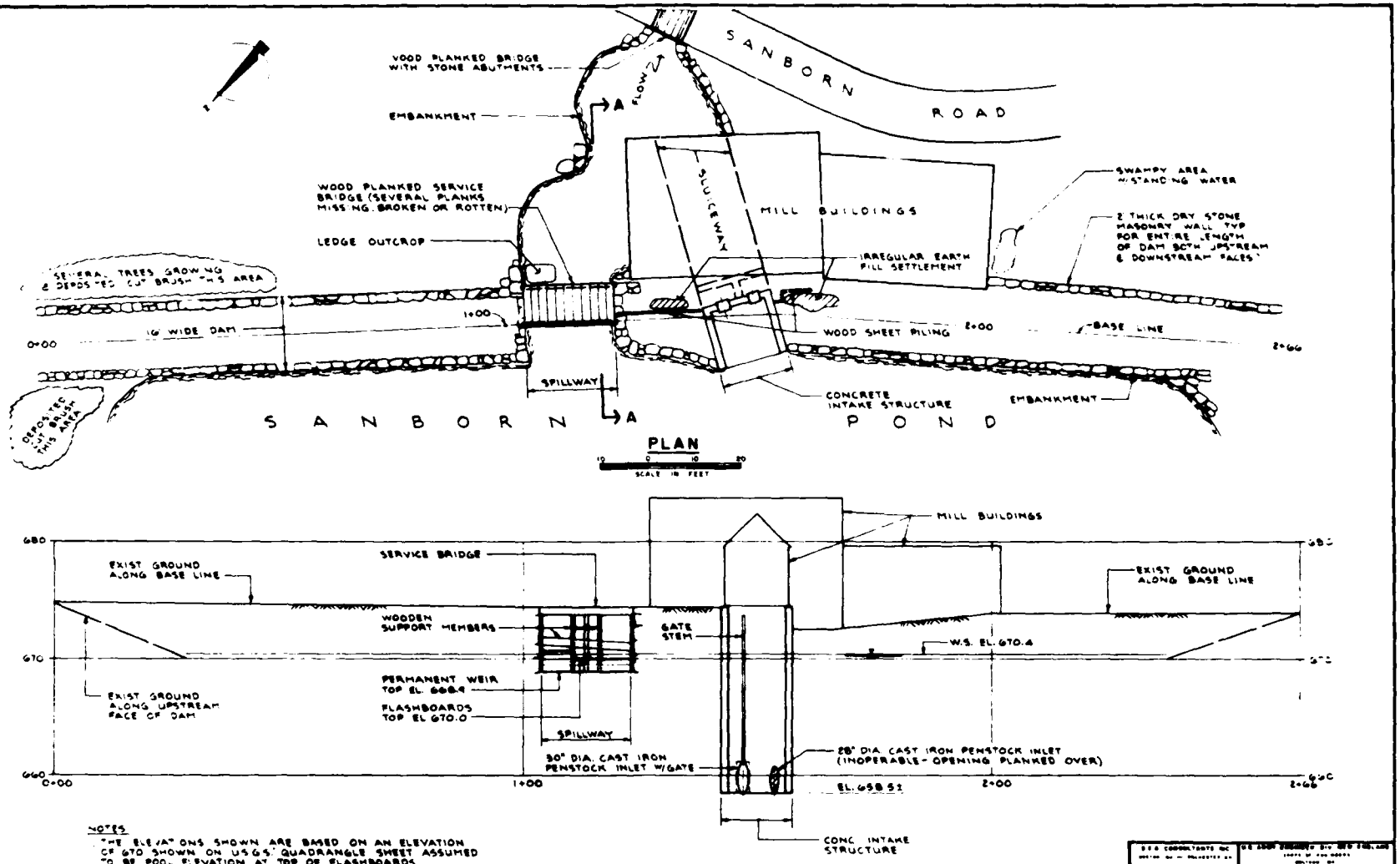
UNITS	NO.	RATED HP	HEAD FEET	C.F.S. FULL GATE	KW	MAKE

USE Conservation Recreation

REMARKS Wheels have been taken out

DATE 7/12/34

PLANS AND DETAILS



PROFILE

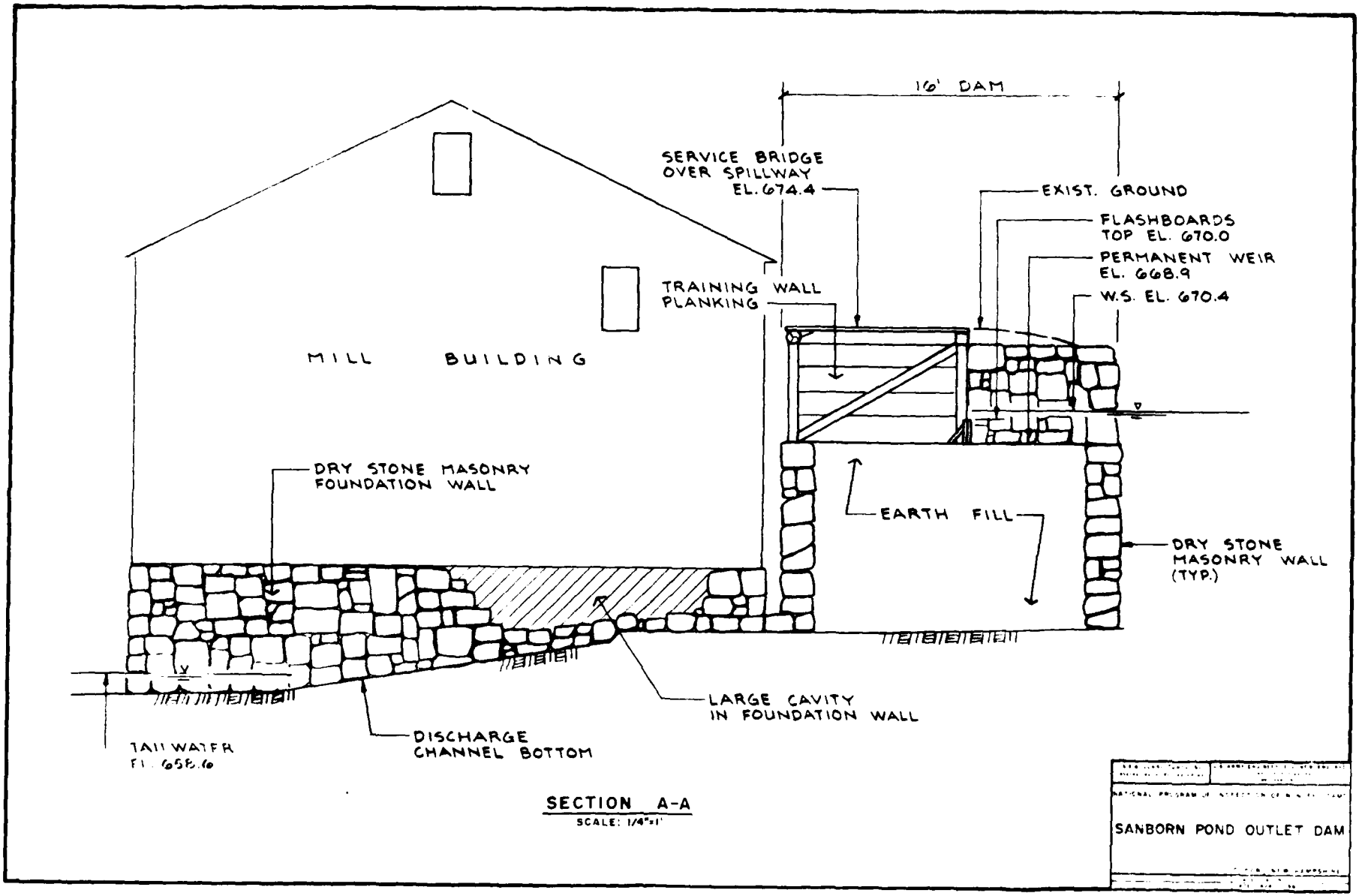
NOTES

1. THE ELEVATIONS SHOWN ARE BASED ON AN ELEVATION OF 670 SHOWN ON USGS QUADRANGLE SHEET ASSUMED TO BE POOL ELEVATION AT TOP OF FLASHBOARDS.
2. THE INFORMATION SHOWN ON THESE DRAWINGS ARE BASED ON EXISTING SKETCHES AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THESE DRAWINGS WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

SANBORN POND OUTLET DAM

LONDON, NEW HAMPSHIRE


16' DAM
SERVICE BRIDGE OVER SPILLWAY EL. 674.4
EXIST. GROUND
FLASHBOARDS TOP EL. 670.0
PERMANENT WEIR EL. 668.9
W.S. EL. 670.4
TRAINING WALL PLANKING
MILL BUILDING
DRY STONE MASONRY FOUNDATION WALL
EARTH FILL
DRY STONE MASONRY WALL (TYP.)
LARGE CAVITY IN FOUNDATION WALL
DISCHARGE CHANNEL BOTTOM
TAILWATER EL. 658.6
SECTION A-A
SCALE: 1/4"=1'
SANBORN POND OUTLET DAM

APPENDIX C

SELECTED PHOTOGRAPHS

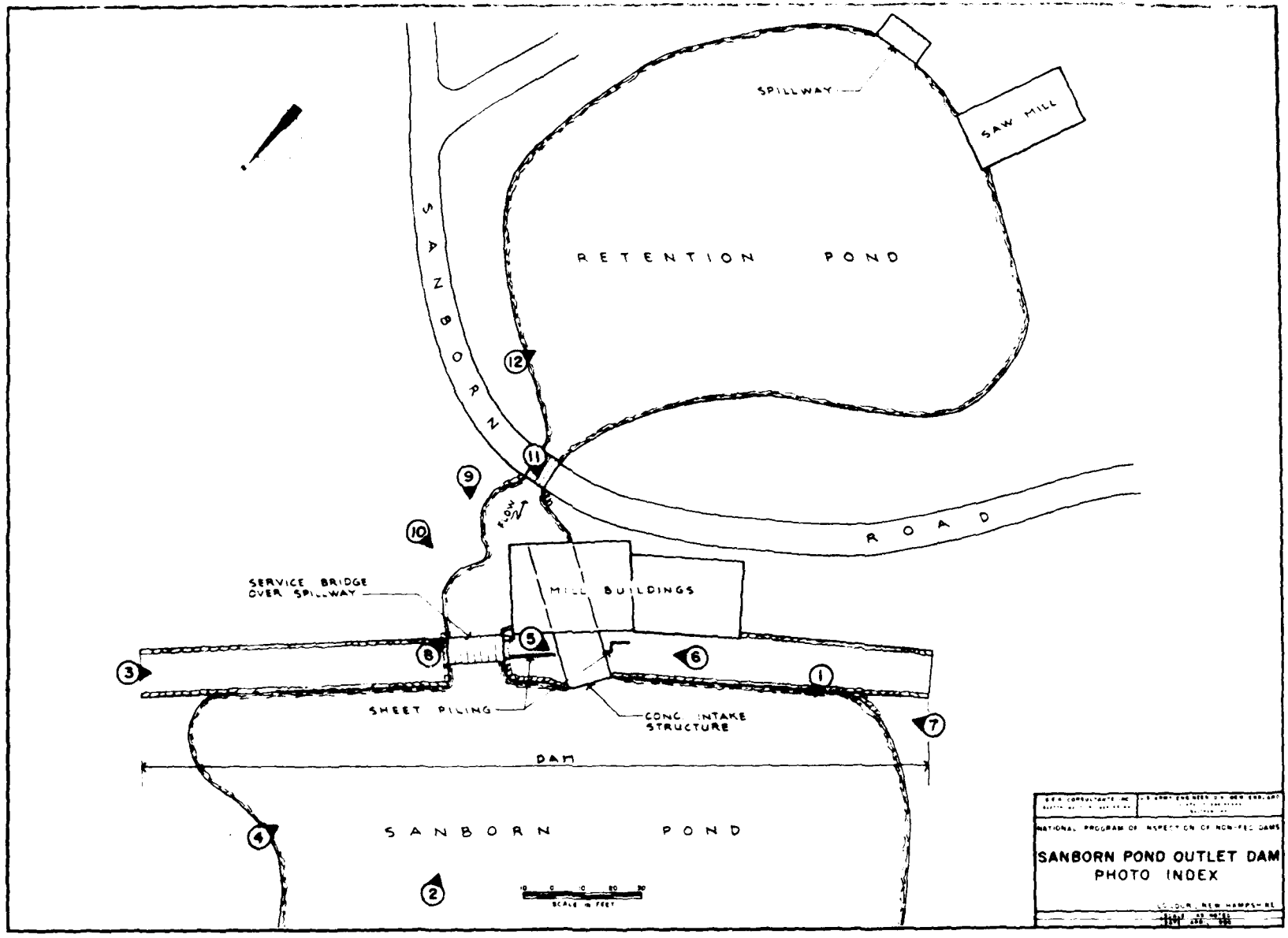

SPILLWAY
SAW MILL
SANBORN
RETENTION POND
ROAD
FLOW
MILL BUILDINGS
SERVICE BRIDGE OVER SPILLWAY
SHEET PILING
CONC INTAKE STRUCTURE
DAM
SANBORN POND
SCALE IN FEET
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS
SANBORN POND OUTLET DAM
PHOTO INDEX

Photo No. 1 - General view of pond from right shoreline.

Photo No. 2 - General view of dam from pond.

Photo No. 5 - Wood plank sheet piling and depression in crest of dam to the left of the mill intake structure.

Photo No. 6 - Wood plank sheet piling and depression in crest of dam to the right of the mill intake structure.

Photo No. 9 - View of downstream face of spillway.

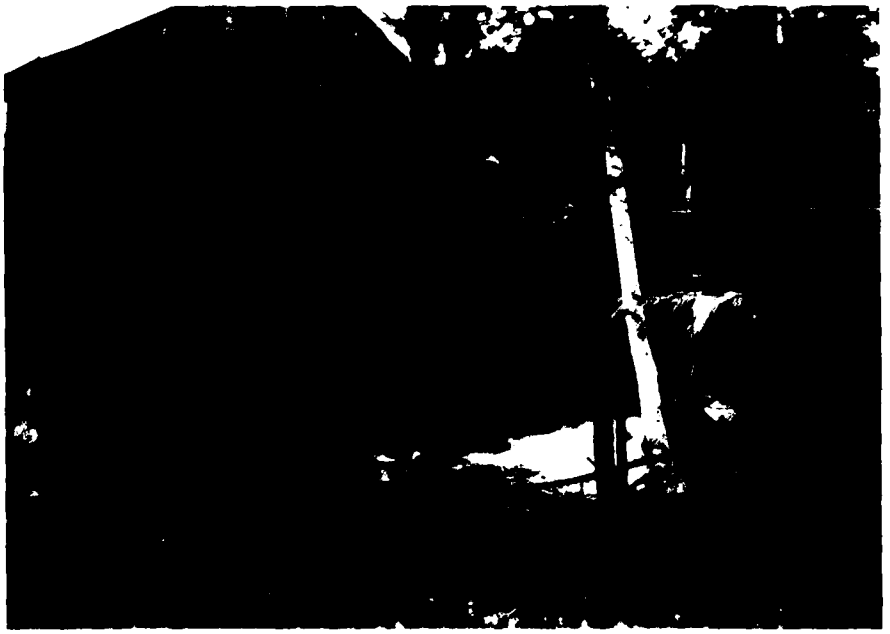
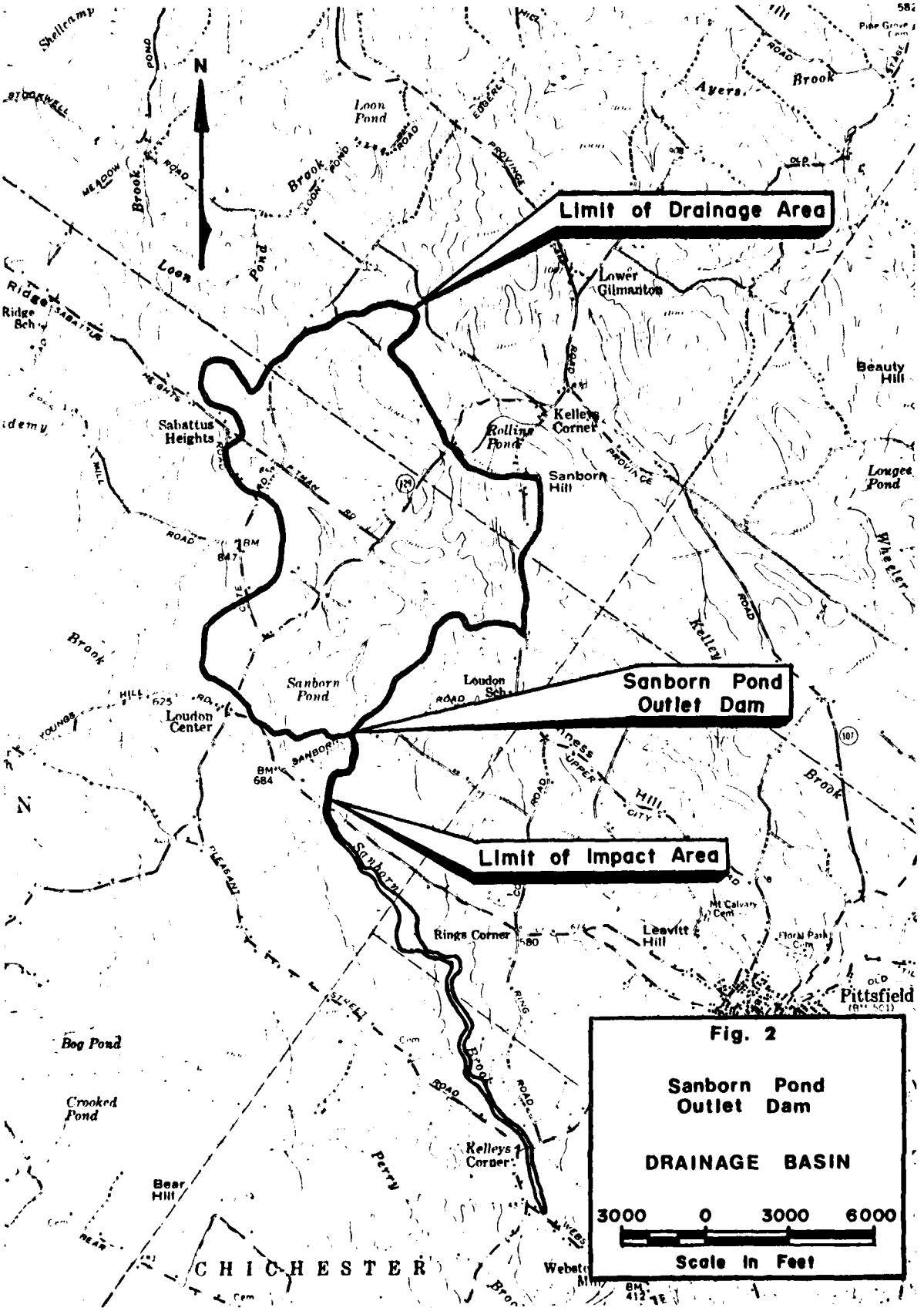


Photo No. 10 - View of mill foundation wall at discharge channel.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS


Limit of Drainage Area
Sanborn Pond Outlet Dam
Limit of Impact Area
N
Loon Pond
Ayers Brook
Lower Gilmanton
Beauty Hill
Kelley Corner
Rolling Pond
Sanborn Hill
Lougee Pond
Sabattus Heights
Ridge
Loudon Center
Sanborn Pond
Rings Corner
Leavitt Hill
Pittsfield
Bog Pond
Crooked Pond
Bear Hill
Kelleys Corner
CHICHESTER
Fig. 2
Sanborn Pond Outlet Dam
DRAINAGE BASIN
3000 0 3000 6000
Scale in Feet

I. Basic Data

A. Drainage Area

1. 4.3 square miles – as defined on USGS sheet and planimetered

2. Drainage area has portions of steeply to moderately sloped terrain surrounding broader flat swampy areas

B. Dam and Storage Information

1. Size Classification: INTERMEDIATE based on storage (≥ 1000 acre-ft and < 50,000 acre-ft)

   as indicated below – storage at crest of dam estimated to be 1,420 acre feet

2. Hazard Potential: Significant hazard

   Failure of dam would cause appreciable damage to saw mill and dam at saw mill. Potential loss of a few lives of individuals working at saw mill

3. Storage Information

Descriptive Information	Elevation * (feet)	Surface * Area (acres)	Storage * (acre-ft)
700' Contour	700	187	
Test flood elevation	676.2	138	1,915
Top of dam	672.5	130	1,420
Spillway crest (top of flashboards)	670.0	125	1,100

* Notes: (1) elevations: NGVD
(2) spillway crest elevation taken to correspond with pool elevation of 670 shown on USGS sheet
(3) surface area at spillway crest taken to correspond with planimetered pool shown on USGS sheet
(4) storage at spillway crest determined by dividing pond into a series of pyramidal frustrums and computing the volume of each frustrum in order to determine the total volume of the pond.

C. Spillway Information

1. Principal spillway located approx 107 feet from left abutment a spillway has a total length of 19 feet, with an effective weir length of 17 feet due to vertical wood supports installed between the training walls. Flashboards have been installed to an elevation of 670 feet, above a wooden spillway deck (elevation ≈ 663.9).

(1) the flashboards are securely fastened in place and it was assumed that they would remain in place for the surcharge storage analysis

b. Discharge over the spillway may be determined with the sharp-crested weir equation

(1) $Q = C L H^{3/2}$ (Standard Handbook for CE's, Mem. 4)

where: Q = discharge, cfs

C = discharge coefficient
L = length of weir, feet
H = head over weir, feet

(2) By the time the water surface reaches the top of the training walls, the spillway weir will be functioning as a submerged weir. Consequently, a C = 3.3 was used for the initial discharge calculation at elevation 671 and above That point C will reduce to 2.7, on a 0.2 incremental basis, since the spillway discharge will approx. broad-crested weir discharge by the time the water depth reaches to top of the training walls

II. Estimate Effect of Surcharge Storage on Maximum Probable Discharge

A. Develop stage - discharge curve for outflow from dam complex

1. define sources of outflow

a discharge over spillway - above elevation 670.0 as defined above

b. discharge over dam crest and abutment

(1) assume grist mill structure remains intact, therefore approximately 75 feet of dam crest not available for discharge

(2) use broad-crested weir equation to calculate discharge over dam and abutments - same as sharp-crested weir equation defined above with C = 2.6

c. assume that penstocks are closed.

2. Discharge over spillway

Elevation (feet)	C	L (feet)	H (feet)	Q (cfs)
670.0	—	17	0	0
671	3.3		1	55
672	3.1		2	150
673	2.9		3	255
674	2.7		4	370
675	2.7		5	510
676	2.7		6	675
677	2.7		7	850
678	2.7		8	1040

3. Discharge over dam and abutments

a. dam crest to left of grist mill

Elevation (feet)	C	Total L (feet)	Avg. H (feet)	Q (cfs)
674.4	2.6	110	0	0
675			0.4	70
676			1.4	475
677			2.4	1,060
678			3.4	1,790

b. left abutment

Elevation (feet)	C	L (feet)	Avg. H (feet)	Q (cfs)
674.8	2.6	0	0	0
675		4	0.1	< 1
676		18	0.6	20
677		32	1.1	95
678		45	1.6	240

c. dam crest to right of grist mill

Elevation (feet)	C	L (feet)	H (feet)	Q (cfs)
673.9	2.6	65	0	0
674	↓	↓	0.1	5
675			1.1	195
676			2.1	515
677			3.1	920
678			4.1	1400

d. right abutment

Elevation (feet)	C	L (feet)	Avg H (feet)	Q (cfs)
673.9	2.6	0	0	0
674	↓	1	0.05	< 1
675		12	0.55	15
676		25	1.05	70
677		37	1.55	185
678		50	2.05	390

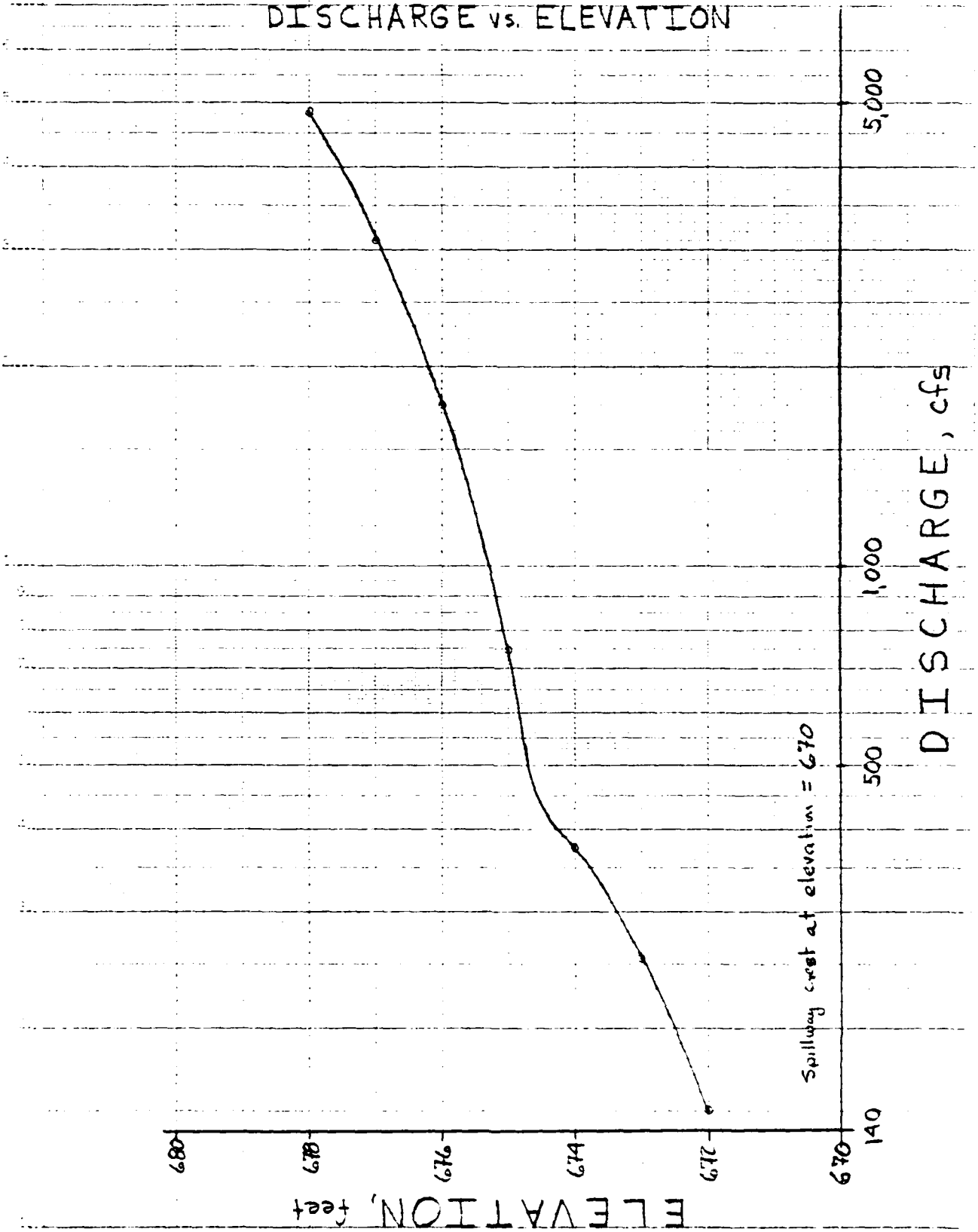
4. Total discharge from dam site – summarized graphically in Figure 1

Elevation (feet)	Q spillway	Q left dam crest	Q left abut	Q right dam crest	Q right abut	Q TOTAL
670	0	0	0	0	0	0
671	55	0	0	0	0	55
672	150	0	0	0	0	150
673	255	0	0	0	0	255
674	370	0	0	5	< 1	375
675	510	70	< 1	195	15	790
676	675	475	20	515	70	1,755
677	850	1,060	95	920	185	3,110
678	1,040	1,790	240	1,400	380	4,850

Sandborn Pond Outlet Dam Job # 274-7901 BWP 9/14/80 KMS

FIGURE 1

DISCHARGE vs. ELEVATION



B. Effect of surcharge storage on max. prob. discharge

1. Pertinent Data

a. Drainage area = 4.3 square miles
b. Characteristics of basin - Portions of steeply sloping to moderately sloping terrain surrounding broader flat swampy areas
c. Test flood = ½ PMF
d. Follow Army Corps' procedure

2. STEP 1: Determine Peak Inflow Q_{P1} from Guide Curve

a. the maximum probable discharge was estimated to be 1,500 cfs/sq.mi. - this maximum probable flood peak flow rate lies between the rolling and flat curves and was selected to reflect the variability of terrain in the drainage area.

$\therefore$ PMF = (1,500 cfs/sq mi)(4.3 sq.mi)

= 6,450 cfs

½ PMF = 3,225 cfs

3. STEP 2: Determine surcharge height to pass Q_{P1}, $STOR_1$, and Q_{P2}

a. from Figure 1 determine surcharge height to pass

Q_{P1} = 3,225 cfs

surcharge elevation = 677.1 feet
elev. spillway weir crest = 670.0 feet
surcharge height = 7.1 feet

b. determine volume of surcharge $STOR_1$ in inches of runoff

(1) first determine volume of storage in acre-ft in following manner

(a) determine surface area of pond corresponding to surcharge elevation from Figure 2 ≈ 140 acres

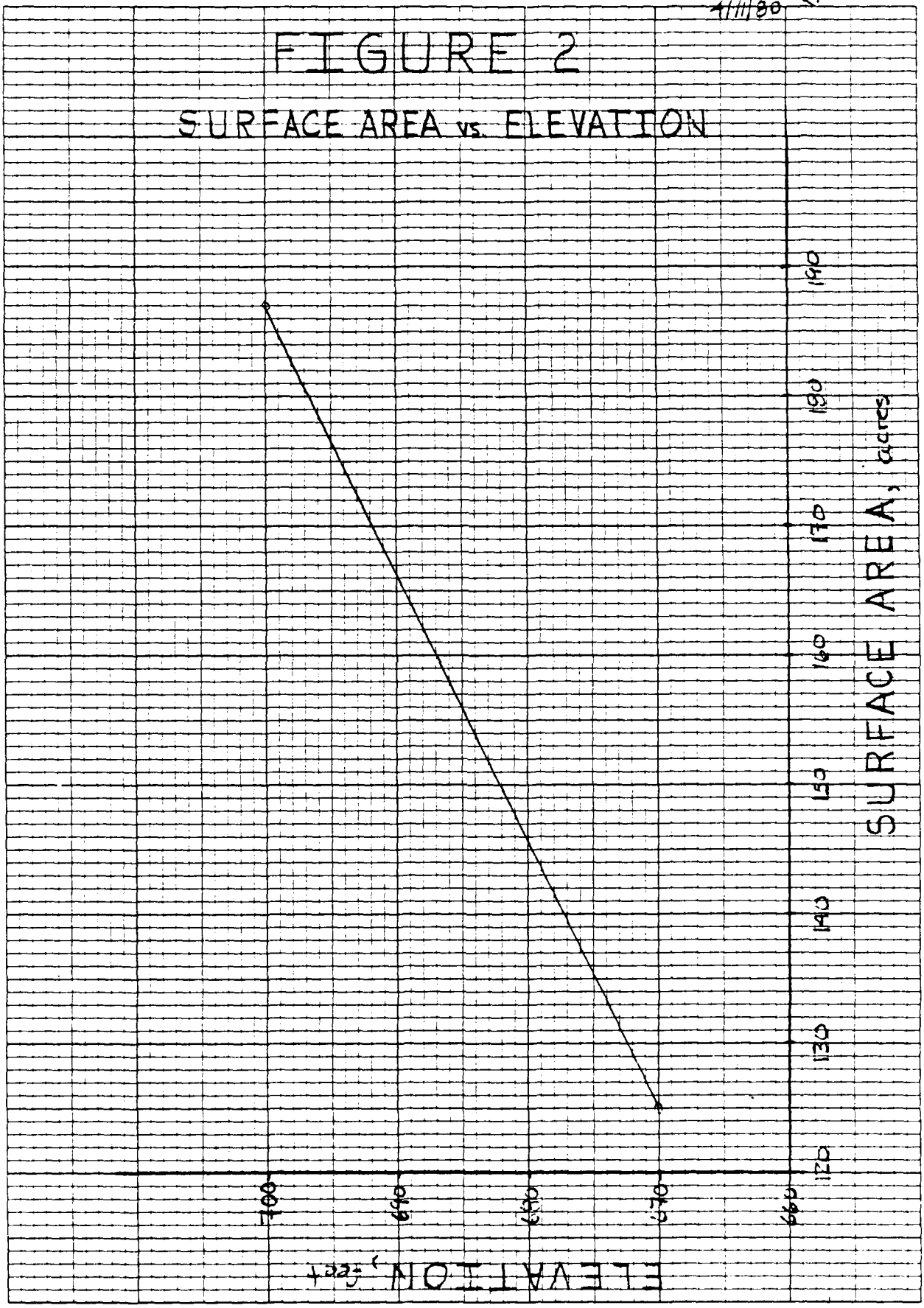
(b) determine average surface area between surcharge elevation and elevation of spillway weir crest.

Sansorn Pond Outlet Dam Job # 274-7901

BJF 4/11/80 KMS

FIGURE 2

SURFACE AREA vs. ELEVATION



(c) multiply average surface by surcharge height and insert in equation below

$$STOR_1 = \frac{\text{Volume of storage (as acre-inches)}}{\text{drainage area}}$$

$$STOR_1 = \frac{\left[\left(\frac{125\text{acres} + 140\text{acres}}{2}\right)(7.1\text{ feet})\right](12"/\text{ft})}{(4.3\text{ sq. mi})(640\text{ acres/sq. mi})}$$

$$STOR_1 = 4.10 \text{ inches}$$

c. determine Q_{P2}

$$Q_{P2} = Q_{P1}\left(1 - \frac{STOR_1}{9.5"}\right)$$

$$Q_{P2} = (3{,}225\text{ cfs})\left(1 - \frac{4.10"}{9.5"}\right)$$

$$Q_{P2} \approx 1{,}830 \text{ cfs}$$

4. STEP 3: Determine surcharge height and $STOR_2$ to pass Q_{P2} and then Q_{P3}

a. From Figure 1 determine surcharge height to pass $Q_{P2} = 1{,}830$ cfs

Surcharge elevation ≈ 676.1 feet
elev. spillway weir crest = 670.0 feet
surcharge height = 6.1 feet

Surface area at surcharge elevation ≈ 139 acres

b. determine $STOR_2$

$$STOR_2 = \frac{\left[\left(\frac{125\,ac + 138\,ac}{2}\right)(6.1\,ft)\right](12"/ft)}{(4.3\,sq.mi)(640\,acres/sq.mi)}$$

$$= 3.50 \text{ inches}$$

c. Average $STOR_1$ and $STOR_2$

$$STOR_{AVG} = \frac{STOR_1 + STOR_2}{2}$$

$$STOR_{AVG} = \frac{4.10\,in. + 3.50\,in}{2}$$

$$STOR_{AVG} = 3.80 \text{ inches}$$

d. determine Q_{P3}

$$Q_{P3} = (3,225\,cfs)\left(1 - \frac{3.80"}{9.5"}\right)$$

$$Q_{P3} = 1,940\,cfs$$

5. STEP 4: Determine surcharge height for Q_{P3} and $STOR_3$

a. from Figure 1 surcharge height for Q_{P3} = 1,935 cfs

surcharge elevation ≈ 676.1
elev. spillway weir crest = 670.0 ft
surcharge height = 6.1 feet

surface area at surcharge elevation ≈ 139 acres

b. determine $STOR_3$

$$STOR_3 = \frac{\left[\left(\frac{125\,ac + 138\,ac}{2}\right)(6.1\,ft)\right](12"/ft)}{(4.3\,sq.mi)(640\,acres/sq.mi)}$$

$STOR_3$ = 3.50 inches

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{3.80\text{ in} + 3.50\text{ in}}{2}$$

$STOR_{AVG}$ = 3.65 inches

d. determine Q_{P4}

$$Q_{P4} = (3{,}225\text{ cfs})\left(1 - \frac{3.65''}{9.5''}\right)$$

Q_{P4} = 1,990 cfs

6. STEP 5: Determine surcharge height for Q_{P4} and $STOR_4$

a. From Figure 1 surcharge height for Q_{P4} = 1,990 cfs

surcharge elevation ≈ 676.2 ft
elevation spillway weir crest = 670.0 ft
surcharge height = 6.2 feet

surface area at surcharge elevation ≈ 138 acres

b. determine $STOR_4$

$$STOR_4 = \frac{\left[\left(\frac{125\text{ ac} + 138\text{ ac}}{2}\right)(6.2\text{ ft})\right](12''/\text{ft})}{(4.3\text{ sq. mi})(640\text{ acres/sq. mi})}$$

$STOR_4$ = 3.56 inches

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{3.65\text{ in} + 3.56\text{ in}}{2}$$

= 3.61 inches

$STOR_4$ and $STOR_{AVG}$ agree to within 2% Therefore accept routed test flood outflow equal to 1,990 cfs and surcharge elevation equal to 676.2 feet

7. In Conclusion

a. Routed test flood outflow ≈ 1,990 cfs will overtop dam (low point - elevation = 672.5 ft) by 3.7 feet

b. Spillway capacity -
(1) water surface at top of dam - elevation = 672.5 ft
(a) flash boards in place

$$Q = (3.0)(17\text{ ft})(672.5' - 670.0')^{3/2} \approx 200\text{ cfs}$$

b. flash boards removed

$$Q = (2.7)(17\text{ft})(672.5' - 668.9')^{3/2} \approx 315\text{ cfs}$$

(1) water surface at test flood elevation - 676.2 ft
(a) flash boards in place

$$Q = (2.7)(17\text{ ft})(676.2' - 670.0')^{3/2} \approx 710\text{ cfs}$$

(b) flash boards removed

$$Q = (2.7)(17\text{ ft})(676.2' - 668.9)^{3/2} \approx 905\text{ cfs}$$

c. penstock capacity -
(1) computed with orifice discharge equation, only 30" operable
(2) water surface at top of dam - elev = 672.5 ft

$$Q = (0.6)(\pi)(1.25)^2\left[(2)(32.2)(672.5' - 659.75')\right]^{1/2} \approx 8\text{+ cfs}$$

(3) water surface at test flood elevation - 676.2 ft

$$Q = (0.6)(\pi)(1.25)^2\left[(2)(32.2)(676.2' - 659.75')\right]^{1/2} \approx 36\text{ cfs}$$

III. Using "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs examine impact of dam failure

1. Pertinent Data

a. Failure occurs when reservoir level at crest of dam - elevation = 672.5

b. Storage at crest elevation estimated to be approximately 1,420 acre-feet

A. Reach 1

1. STEP 1: Determine reservoir storage at time of failure

from previous calcs. storage = 1,420 acre-feet

2. STEP 2: Determine Peak Failure Outflow Q_{P1}

$$Q_{P1} = (8/27)\, W_b \sqrt{g}\, Y_o^{3/2}$$

where: W_b = Breach width (use 40% of total length
= (0.4)(265 feet)
= 106 feet

Y_o = Total height from channel bed to pool level at failure

$Y_o \approx 14$ feet

$$Q_{P1} = (8/27)(106 \text{ feet})(32.2)^{1/2}(14 \text{ feet})^{3/2}$$

Q_{P1} = 9,340 cfs

The pre failure discharge is negligible compared to the failure discharge and consequently was not considered with these calculations.

3. STEP 3: Prepare stage - discharge Curve for Reach 1

a. Pertinent Data

(1) Discharge through reach controlled by dam at saw mill

(2) discharge calculations over the spillway, dam, and abutments included in Section IV of the Hydrologic Calcs.

(3) see Figure 3 for stage - discharge curve

4. STEP 4: Estimate Reach Outflow

a Determine stage for Q_{P1} = 9,340 cfs from Figure 3 and find volume in reach

(1) stage = 9.6 feet

(2) Volume in reach = (Stage)(average surface area of pond *)

* see Figure 7 in Section IV of Hydrologic Calcs. for Surface area vs Elevation

$$\text{Volume} = V_1 = (9.6\text{ ft})\left(\frac{0.3\text{ acres} + 1.2\text{ acres}}{2}\right)$$

$$V_1 = 7.2\text{ acre-ft}$$

$$V_1 < \frac{S}{2} \therefore \text{reach length OK}$$

b. Determine $Q_{P2(TRIAL)}$

$$Q_{P2(TRIAL)} = (Q_{P1})\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P2(TRIAL)} = (9{,}340 \text{ cfs})\left(1 - \frac{7.2}{1420}\right)$$

$$Q_{P2(TRIAL)} = 9{,}290 \text{ cfs}$$

c. Compute V_2 using $Q_{P2(TRIAL)}$

From Figure 3 determine stage for $Q_{P2(TRIAL)}$

$$\text{Stage} = 9.6 \text{ feet}$$

$$V_2 = (9.6 \text{ ft})\left(\frac{0.3 \text{ acres} + 1.2 \text{ acres}}{2}\right)$$

$$V_2 = 7.2 \text{ acre-ft}$$

d. Average V_1 and V_2 and compute Q_{P2}

(1) $$V_{avg} = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{7.2 \text{ ac-ft} + 7.2 \text{ ac-ft}}{2}$$

$$V_{avg} = 7.2 \text{ acre-ft}$$

(2) $$Q_{P2} = Q_{P1}\left(1 - \frac{V_{avg}}{S}\right)$$

$$Q_{P2} = (9{,}340 \text{ cfs})\left(1 - \frac{7.2}{1420}\right)$$

$$Q_{P2} = 9{,}290 \text{ cfs}$$

B. Reach 2

1. STEP 3: Prepare stage-discharge curve for Reach 2

   a. Pertinent Data

      (1) Reach length = 4,300 feet
      (2) Channel slope = 0.019
      (3) Manning n = 0.05
      (4) Channel shape - trapezoidal
      (5) Base width ≈ 10 feet

   b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

   a. Determine stage for Q_{P2} = 9,290 cfs from Figure 3 and find volume in reach

      (1) Stage (depth of flow) = 8.2 feet

      (2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(8.2\text{ ft})(10\text{ ft} + 210\text{ ft}) = 902\text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(902\text{ ft}^2)(4300\text{ ft})}{43{,}560\text{ ft}^2/\text{acre}} = 89.0\text{ acre-feet}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

   b. Determine $Q_{P3(TRIAL)}$

$$Q_{P3(TRIAL)} = Q_{P2}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P3(TRIAL)} = (9{,}290\text{ cfs})\left(1 - \frac{89.0}{1420}\right)$$

$$Q_{P3(TRIAL)} \approx 8{,}710\text{ cfs}$$

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PROJECT Sanborn Pond Outlet Dam | COMPUTED BY BWP | DATE 4/14/80
DETAIL Hydrologic Calcs | CK'D. BY KMS | DATE 4/16/80

c. Compute V_2 using $Q_{P3(TRIAL)}$

From Figure 3 determine stage for $Q_{P3(TRIAL)}$

Stage = 8.0 feet

X-area = (0.5)(8.0 ft)(10 ft + 200 ft)

= 840 ft^2

$$V_2 = \frac{(840\ ft^2)(4,300\ ft)}{43,560\ ft^3/acre}$$

V_2 = 82.9 acre-ft

d. Average V_1 and V_2 and compute Q_{P3}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{89.0\ ac\text{-}ft + 82.9\ ac\text{-}ft}{2}$$

V_{avg} = 85.9 acre-ft

(2) $Q_{P3} = Q_{P2}\left(1 - \frac{V_{avg}}{S}\right)$

$$Q_{P3} = (9,290\ cfs)\left(1 - \frac{85.9}{1420}\right)$$

Q_{P3} = 8,730 cfs

C. Reach 3

1. STEP 3: Prepare stage-discharge curve for Reach 3

a. Pertinent Data

(1) Reach length = 1,200 feet
(2) Channel slope = 0.019
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 20 feet

b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P3} = 8,730 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 5.2 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(5.2 \text{ ft})(20 \text{ ft} + 390 \text{ ft})$$
$$= 1066 \text{ ft}^2$$
$$\text{Volume} = V_1 = \frac{(1066 \text{ ft}^2)(1,200 \text{ ft})}{43,560 \text{ ft}^2/\text{acre}}$$
$$= 29.4 \text{ acre-feet}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P4(TRIAL)}$

$$Q_{P4(TRIAL)} = Q_{P3}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P4(TRIAL)} = (8,730 \text{ cfs})\left(1 - \frac{29.4}{1420}\right)$$

$$Q_{P4(TRIAL)} = 8,550 \text{ cfs}$$

c. Compute V_2 using $Q_{P4(TRIAL)}$

From Figure 3 determine stage for $Q_{P4(TRIAL)}$

Stage = 5.2 feet

X-area = (0.5) (5.2 ft)(20 ft + 390 ft)
≈ 1066 ft^2

$$V_2 = \frac{(1{,}066\ ft^2)\ (1{,}200\ ft)}{43{,}560\ ft^2/acre}$$

V_2 = 29.4 acre-feet

d. Average V_1 and V_2 and comp... Q_{P4}

(1) $$Vavg = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{29.4\ ac\text{-}ft + 29.4\ ac\text{-}ft}{2}$$

Vavg = 29.4 acre-ft

(2) $$Q_{P4} = Q_{P3}\left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P4} = (8{,}730\ cfs)\left(1 - \frac{29.4}{1420}\right)$$

Q_{P4} = 8,550 cfs

D. Reach 4

1. STEP 3: Prepare stage-discharge curve for Reach 4

a. Pertinent Data

(1) Reach length = 4,100 feet
(2) Channel slope = 0.0049
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 20 feet

b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P4} = 8,550 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 6.8 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(6.8\text{ ft})(20\text{ ft} + 510\text{ ft}) = 1802\text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(1802\text{ ft}^2)(4100\text{ ft})}{43{,}560\text{ ft}^2/\text{acre}}$$

$$= 170\text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P5(TRIAL)}$

$$Q_{P5(TRIAL)} = Q_{P4}\left(1 - \frac{\quad}{\quad}\right)$$

$$Q_{P5(TRIAL)} = (8{,}550\text{ cfs})\left(1 - \frac{170}{1420}\right)$$

$$Q_{P5(TRIAL)} = 7{,}530\text{ cfs}$$

c. Compute V_2 using $Q_{P5(TRIAL)}$

From Figure 3 determine stage for $Q_{P5(TRIAL)}$

Stage = 6.4 feet

X-area = $(0.5)(6.4\text{ ft})(20\text{ ft} + 480\text{ ft})$

$= 1600\text{ ft}^2$

$$V_2 = \frac{(1600\text{ ft}^2)(4100\text{ ft})}{43{,}560\text{ ft}^2/\text{acre}}$$

V_2 = 150 acre-ft

d. Average V_1 and V_2 and compute Q_{P5}

(1) $$V_{avg} = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{170\text{ ac-ft} + 150\text{ ac-ft}}{2}$$

V_{avg} = 160 acre-feet

(2) $$Q_{P5} = Q_{P4}\left(1 - \frac{V_{avg}}{S}\right)$$

$$Q_{P5} = (8{,}550\text{ cfs})\left(1 - \frac{160}{1420}\right)$$

Q_{P5} = 7,590 cfs

E. Reach 5

1. STEP 3: Prepare stage-discharge curve for Reach 5

a. Pertinent Data

(1) Reach length = 800 feet
(2) Channel slope = 0.025
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 20 feet

b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{p5} = 7,590 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 4.7 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(4.7\text{ ft})(20\text{ ft} + 350\text{ ft})$$
$$= 870\text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(870\text{ ft}^2)(800\text{ ft})}{43{,}560\text{ ft}^2/\text{acre}}$$

$$= 16.0\text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P6(TRIAL)}$

$$Q_{P6(TRIAL)} = Q_{p5}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P6(TRIAL)} = (7{,}590\text{ cfs})\left(1 - \frac{16.0}{1420}\right)$$

$$Q_{P6(TRIAL)} = 7{,}500\text{ cfs}$$

c. Compute V_2 using $Q_{P6(TRIAL)}$

From Figure 3 determine stage for $Q_{P6(TRIAL)}$

Stage = 4.7 feet

X-area = $(0.5)(4.7\ ft)(20\ ft + 350\ ft)$

$= 870\ ft^2$

$$V_2 = \frac{(870\ ft^2)(800\ ft)}{43,560\ ft^3/acre}$$

$V_2 = 16.0$ acre-ft

d. Average V_1 and V_2 and compute Q_{P6}

(1) $Vavg = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{16.0\ ac\text{-}ft + 16.0\ ac\text{-}ft}{2}$$

$Vavg = 16.0$ ac-ft

(2) $Q_{P6} = Q_{P5}\left(1 - \frac{Vavg}{S}\right)$

$$Q_{P6} = (7,590\ cfs)\left(1 - \frac{16.0}{1420}\right)$$

$Q_{P6} = 7,500$ cfs

F. Reach 6

1. STEP 3: Prepare stage-discharge curve for Reach 6

a. Pertinent Data

(1) Reach length = 6,200 feet
(2) Channel slope = 0.0029
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 20 feet

b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P6} = 7,500 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 7.1 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(7.1\text{ ft})(20\text{ ft} + 530\text{ ft})$$
$$= 1953\text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(1{,}953\text{ ft}^2)(6{,}200\text{ ft})}{43{,}560\text{ ft}^2/\text{acre}}$$

$$= 278\text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P7(TRIAL)}$

$$Q_{P7(TRIAL)} = Q_{P6}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P7(TRIAL)} = (7{,}500\text{ cfs})\left(1 - \frac{278}{1420}\right)$$

$$Q_{P7(TRIAL)} = 6{,}030\text{ cfs}$$

c. Compute V_2 using $Q_{P7(TRIAL)}$

From Figure 3 determine stage for $Q_{P7(TRIAL)}$

Stage = 6.5 feet

X-area = (0.5)(6.5 ft)(20 ft + 490 ft)
= 1658 ft²

$$V_2 = \frac{(1658\ ft^2)(6200\ ft)}{43{,}560\ ft^2/acre}$$

V_2 = 236 acre-ft

d. Average V_1 and V_2 and compute Q_{P7}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{278\ ac\text{-}ft + 236\ ac\text{-}ft}{2}$$

V_{avg} = 257 acre-ft

(2) $Q_{P7} = Q_{P6}\left(1 - \frac{V_{avg}}{S}\right)$

$$Q_{P7} = (7{,}500\ cfs)\left(1 - \frac{257}{1420}\right)$$

Q_{P7} = 6,140 cfs

G. Reach 7

1. STEP 3: Prepare stage-discharge curve for Reach 7

   a. Pertinent Data

      (1) Reach length = 5,600 feet
      (2) Channel slope = 0.011
      (3) Manning n = 0.05
      (4) Channel shape - trapezoidal
      (5) Base width ≈ 20 feet

   b. See Figure 3 for stage-discharge curve

2. STEP 4: Estimate Reach Outflow

   a. Determine stage for Q_{P7} = 6,140 cfs from Figure 3 and find volume in reach

      (1) Stage (depth of flow) = 7.4 feet

      (2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(7.4 \text{ ft})(20 \text{ ft} + 185 \text{ ft}) = 759 \text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(759 \text{ ft}^2)(5{,}600 \text{ ft})}{43{,}560 \text{ ft}^2/\text{acre}} = 97.5 \text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

   b. Determine $Q_{P8(TRIAL)}$

$$Q_{P8(TRIAL)} = Q_{P7}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P8(TRIAL)} = (6{,}140 \text{ cfs})\left(1 - \frac{97.5}{1420}\right)$$

$$Q_{P8(TRIAL)} = 5{,}720 \text{ cfs}$$

c. Compute V_2 using $Q_{PB(TRIAL)}$

From Figure 3 determine stage for $Q_{PB(TRIAL)}$

Stage = 7.2 feet

X-area = (0.5)(7.2 ft)(20 ft + 180 ft)

= 720 ft^2

$$V_2 = \frac{(720\ ft^2)(5600\ ft)}{43,560\ ft^2/acre}$$

V_2 = 92.5 acre-ft

d. Average V_1 and V_2 and compute Q_{PB}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{97.5\ ac\text{-}ft + 92.5\ ac\text{-}ft}{2}$$

V_{avg} = 95 acre-ft

(2) $Q_{PB} = Q_{P7}\left(1 - \frac{V_{avg}}{S}\right)$

$$Q_{PB} = (6,140\ cfs)\left(1 - \frac{95}{1420}\right)$$

Q_{PB} = 5,730 cfs

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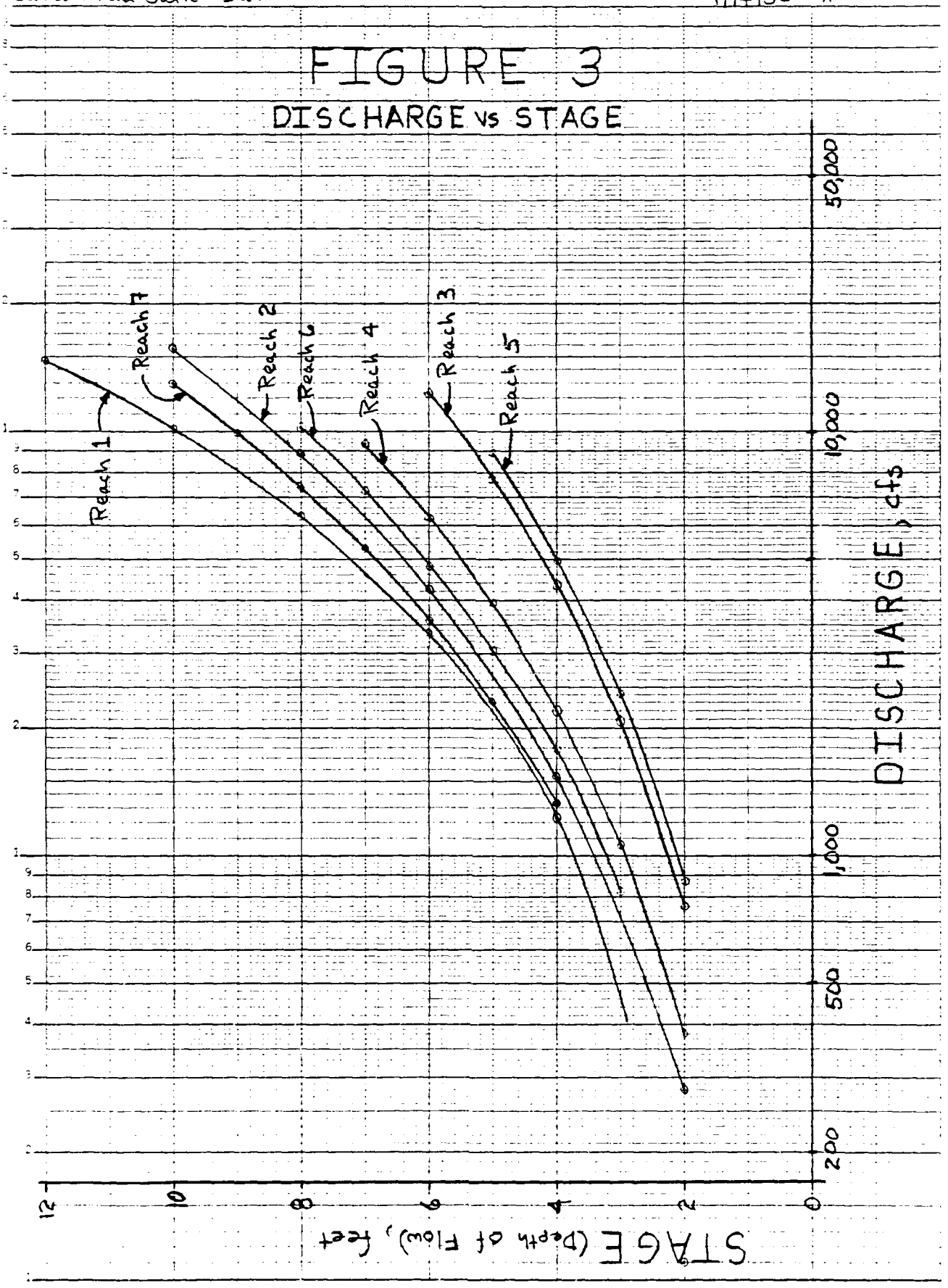
FIGURE 3

DISCHARGE vs STAGE



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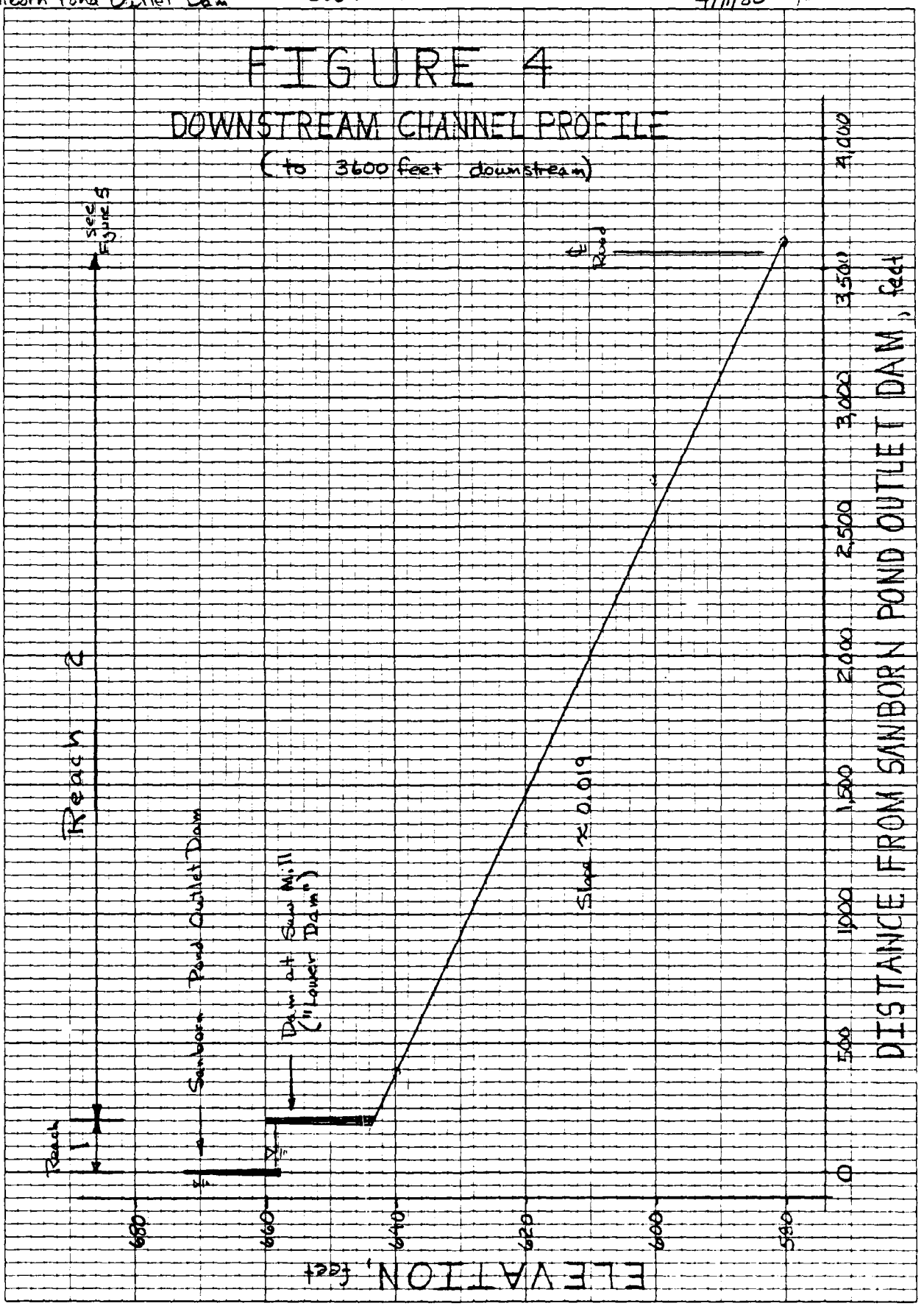

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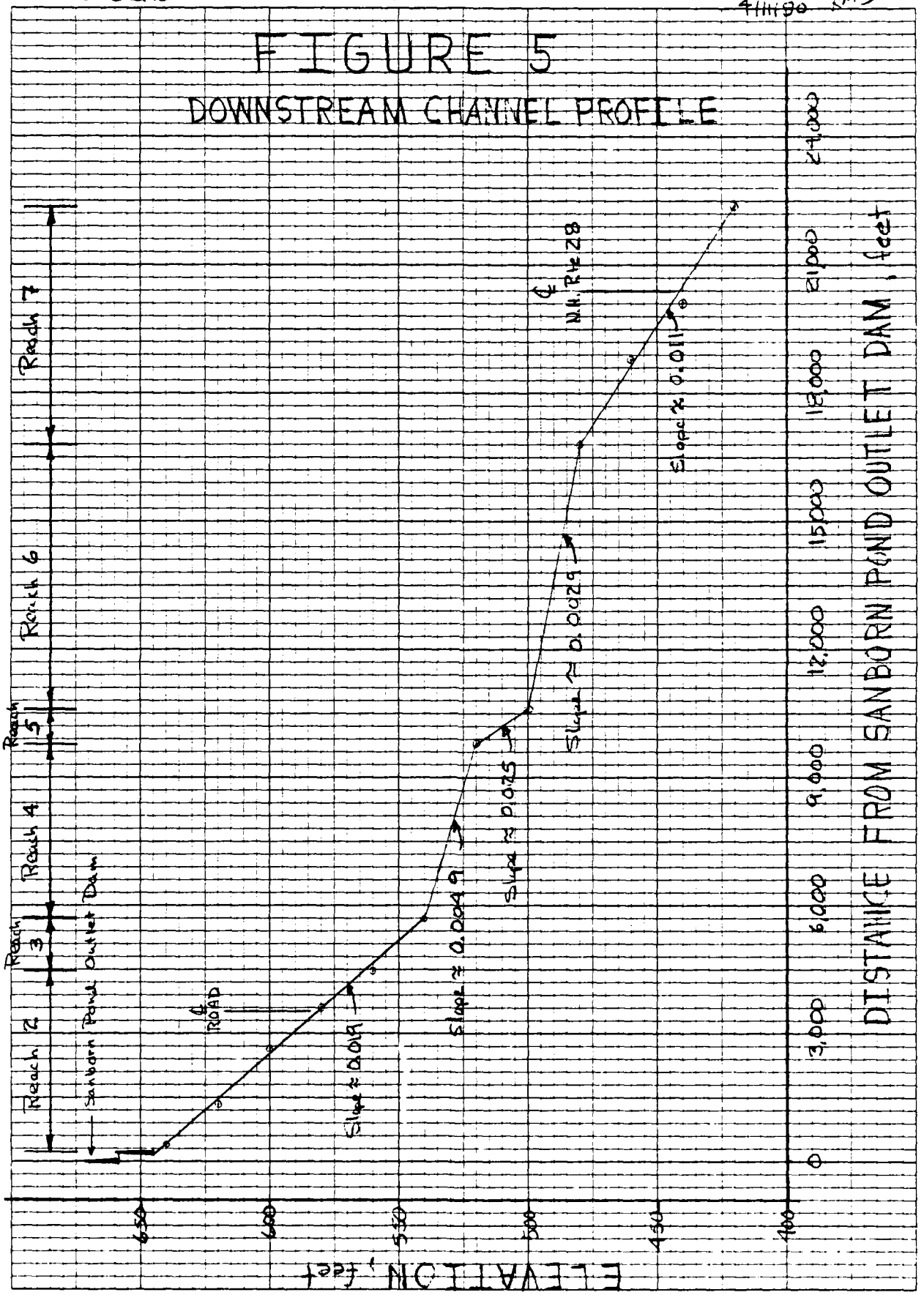
EWF 4/11/90 MS

FIGURE 5

DOWNSTREAM CHANNEL PROFILE



IV Stage - Discharge Calculations for Reach 1 - Lower Dam

A. Discharge from Reach 1 will be controlled by dam (labeled "Lower Dam" in subsequent discussion) just below Sanborn Pond Outlet Dam

1. Pertinent Data

a. Spillway -
(1) flat wood deck
(2) ≈ 15 feet long
(3) elevation of crest ≈ 658

b. dam
(1) ≈ 150 feet long
(2) saw mill reduces effective weir length by 25 feet
(3) cross section shown in Figure 6

B. Discharge from lower dam site

1. Discharge over spillway, dam and abutments computed with broad-crested weir equation

$$Q = C\,L\,H^{3/2}$$

where Q = discharge, cfs
C = discharge coeff = 2.6
L = length of weir, ft.
H = head over weir, ft.

2. Discharge over spillway

Elevation (feet)	C	L (feet)	H (feet)	Q (cfs)
658	2.6	15	0	0
660	↓	↓	2	110
662	↓	↓	4	310
664	↓	↓	6	570
666	↓	↓	8	880
668	↓	↓	10	1,230
670	↓	↓	12	1,620

3 Discharge over dam

Elevation (feet)	C	L (feet)	H (feet)	Q (cfs)
660	2.6	110	0	0
662	↓	↓	2	810
664	↓	↓	4	2,290
666	↓	↓	6	4,200
668	↓	↓	8	6,470
670	↓	↓	10	9,040

4. Discharge over abutments

Elevation (feet)	C	Total L (feet)	Avg H (feet)	Q (cfs)
660	2.6	0	0	0
662	↓	40	1	100
664	↓	65	2	480
666	↓	90	3	1,220
668	↓	115	4	2,390
670	↓	140	5	4,070

5 Total Discharge from "Lower Dam" site

Elevation (feet)	Q spillway	Q dam	Q abutments	Q TOTAL
658	0	0	0	0
660	110	0	0	110
662	310	810	100	1,220
664	570	2,290	480	3,340
666	880	4,200	1,220	6,300
668	1,230	6,470	2,390	10,090
670	1,620	9,040	4,070	14,730

Stage-Discharge data summarized graphically in Figure 3, Section III of the Hydrologic Calculations

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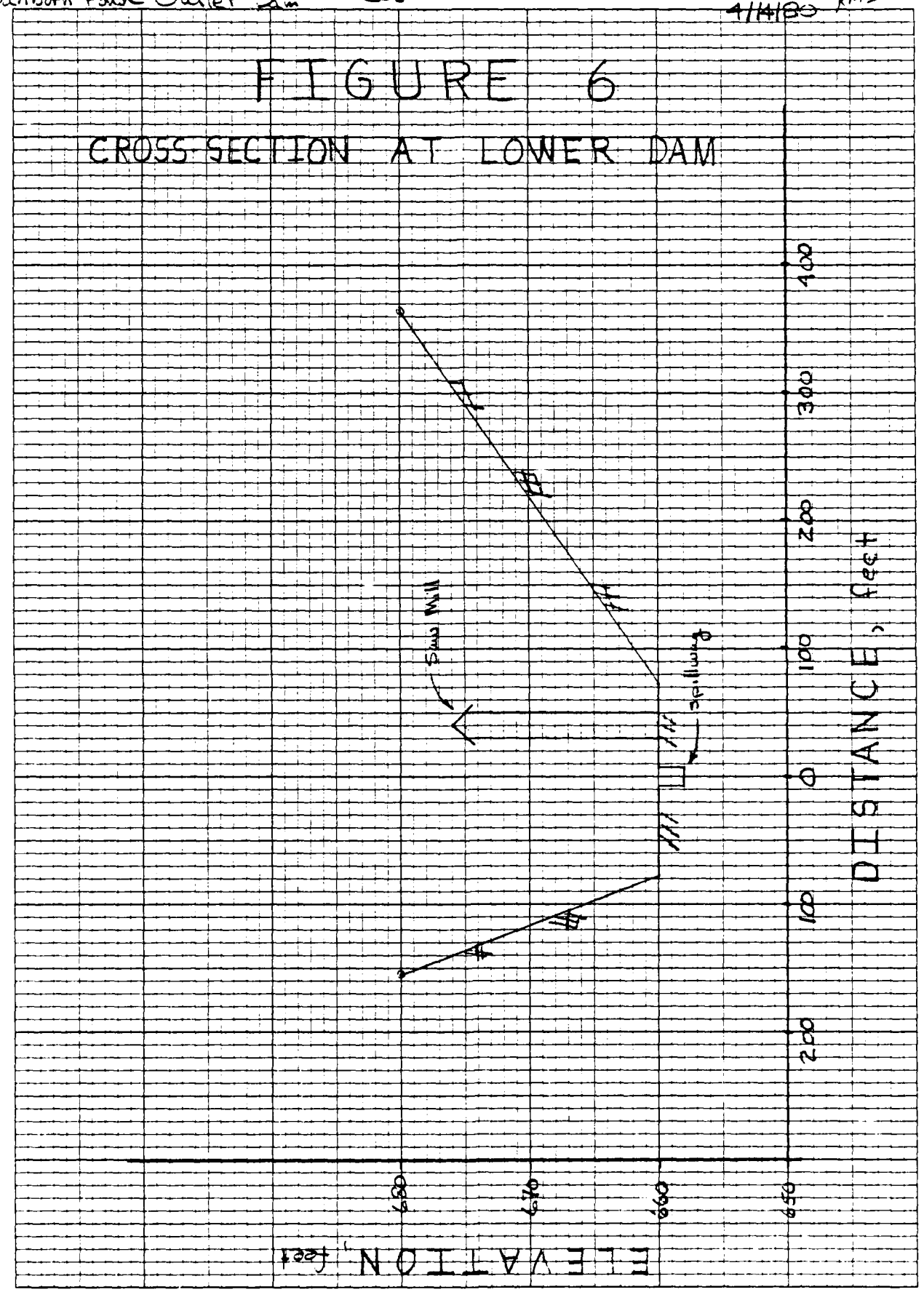
FIGURE 6

CROSS SECTION AT LOWER DAM



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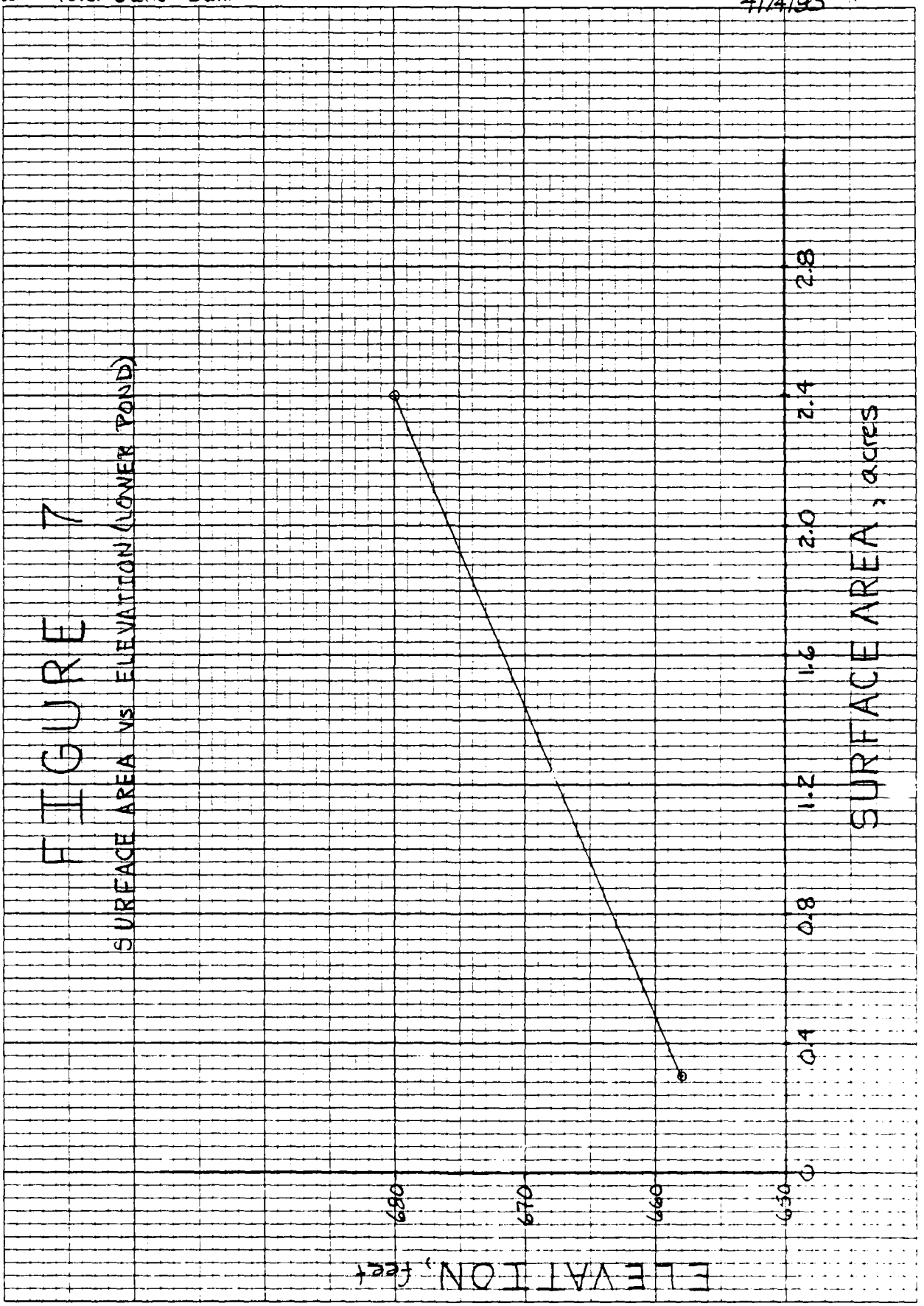

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